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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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Communications, which should briefly outline the suggested improvement, should, in the first place, be addressed to the undersigned, if possible, not later than MONDAY, 29th JANUARY, 1917.

WALTER DIXON, M.I.M.E., M.I.E.E.,
Interim Secretary,
28, BATH STREET,
GLASGOW. F 941

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IN THE MATTER OF THE TRADING WITH THE ENEMY AMENDMENT ACT, 1916.

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Tenders for the Purchase of

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H.M. Office of Works, &c.,
17th January, 1917. F 972

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17th January, 1917. F 973

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Town Hall, Brighton,
19th January, 1917. F 962

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18th January, 1917. F 963

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REQUIRED (London), one with experience in Mechanical Engineering and Lay-out of Plant; and one with Mechanical and Electrical experience. No person already engaged on Government work, or resident more than 10 miles away need apply.—Reply, giving particulars of experience and salary required, to Z.O. 109, care of DEACONS, Leadenhall Street, E.C. G 20

Wanted, Draughtsman for

Controlled Establishment. One with knowledge of grinding and seed crushing plant preferred but not essential. No one already engaged on Government work need apply.—Apply, stating full particulars and salary required, to your nearest LABOUR EXCHANGE, mentioning this Journal and F 965.

Draughtsman.—Wanted, for

Jigs, Tools and Fixtures for Automobile details in Government controlled establishment. Previous experience essential. State age and salary required.
No man at present on Government work need apply.
Applications, in the first instance, should be made to the nearest BOARD OF TRADE EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 2647. F 967

Wanted, at Once, for Con-

trolled Establishment in South Wales, an experienced TRACER (Male), also able to make detail drawings. No person already on Government work will be engaged.—Applicants should state age, previous experience, and wages required to their nearest EMPLOYMENT EXCHANGE, quoting No. A 2817. G 23

Wanted, Traveller, calling on

large Engineering Firms, to introduce WIRE BRUSH for cleaning Files and Machinery; on commission.—Apply by letter, stating ground covered, to SAUNDERS & BARTLETT, Melville Terrace, Bedminster, Bristol. F 994

Wanted, Assistant, ex-

perienced in Estimating for Machine Tools, etc. Will be required to act on own initiative and follow resulting orders right through. Must be ineligible for the Army. State age, salary and previous experience. No one resident more than ten miles away or already engaged on Government work will be employed.—Address, G 18, Offices of ENGINEERING.

An Opening Occurs in a

Patent Agent's Office for an ASSISTANT who has had technical training and a good education.—Address, in the first instance, G 1, Offices of ENGINEERING.

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in the Midlands, have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, A 750, Offices of ENGINEERING.

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Plant and Maintenance En-

gineer, mechanical and electrical, experienced chief draughtsman, designer and erector heaviest steam turbine practice, electric power stations, REQUIRES responsible POSITION, highest credentials, ineligible.—Address, F 120, Offices of ENGINEERING.

Mechanical Engineer,

Russian, with academic training, wide technical and commercial experience in this country and on the Continent, knowledge of languages, SEEKS responsible POSITION, or would accept first-class Agencies for Russia.—Address, F 899, Offices of ENGINEERING.

Wanted, Position as Engineer

in charge of steam plant for pumping, electrical, or other purposes. Over 20 years' experience as chief engineer of steamers engaged in Atlantic trade. Good references.—Address, G 19, Offices of ENGINEERING.

Engineer (46), B.Sc.,

A.M.I.E.E., with experience in steam and petrol engines, turbines, power stations, heating and ventilating, patents, &c., last eight years engineering lecturer, SEEKS POST of interesting kind in works or office.—Address, A.M., 23, Grove Road, Brixton, S.W. G 9

Engineer (36), M.I.M.E., Occu-

pying important executive position, splendid works and commercial experience, good organiser, possesses energy and initiative, good technical and mathematical knowledge, DESIRES CHANGE after the war. Works manager or similar.—Address, G 7, Offices of ENGINEERING.

Buyer to Manufacturing

Electrical or Mechanical Engineers is OPEN to ENGAGEMENT. Fifteen years' experience in the purchasing of raw and finished materials. Wide knowledge of markets; good organiser and manager. —Address, F 981, Offices of ENGINEERING.

Tool and Grinding Expert,

finishing contract, RE-ENGAGEMENT, home or other Allied country; mixed labour experience. Lumsden method of high production of tools and cutters a speciality.—Address, F 945, Offices of ENGINEERING.

TESTING MODEL AEROPLANES.

THE calm unhurried investigations carried out under the auspices of the American National Advisory Committee for Aeronautics,* having for their object the complete analysis of the causes that make for stability in aeroplanes, contrast vividly with the importunity exhibited by the British public, impatient for the production of some new and more powerful aircraft, that will give greater efficiency on the battlefield and ensure supremacy over any form of construction that an alert and energetic enemy may devise. But even in our feverish haste for visible results the leisurely inquiry may serve to remind us that we as yet know neither the nature of the qualities that are most to be desired in a war aeroplane, nor the form and character of the mechanism that will best secure a particular object. Our procedure cannot afford to be tentative. In a state of hurry and excitement it seems too like trifling to carry on the experiments that mathematical research may indicate as useful or necessary. While the cry goes up "for a constant and liberal supply of the most up-to-date machines," achievement rather than experiment is expected from our leaders. A harassed aircraft minister, who has to reassure and appease an uninformed and clamorous public, fed on isolated and sensational scraps of intelligence, looks for relief rather to the workshop than to the laboratory. Nor can it be said that the American investigations will lighten the labour of our experts or lessen their responsibility. The Americans have not to consider the war aeroplane carrying an indispensable armament that demands constructional arrangements possibly incompatible with those that purely scientific deductions suggest as best adapted. Moreover, the inquiry is directed solely to one end, dynamic stability, and though in public estimation this property is considered of the utmost importance, some other desirable conditions, such as swiftness of ascent, diminished drift, and other qualities are highly valued by our flying experts. Stability, inherent stability, can easily be overrated. It is possible that the aeroplanes of the future will be only slightly stable, and that swiftness and certainty of control by the pilot will be the qualities most in demand. Pilots are growing distrustful of very stable aeroplanes, whose motion is liable to become so violent in gusts that the pilot's control is seriously impaired, giving the aeroplane a chance to "take charge" at a critical moment.

It is essential that much experimental work should be carried out with models, since this plan permits a succession of variations to be made in any one feature of a design, and the effect of each alteration to be easily traced. Some of the data needed for discussion can only be derived from models, and though the relation of these to full-sized aeroplanes has been worked out carefully, and generally successfully, a source of error is undoubtedly introduced in arguing from one to the other. It is usual to assume that the force on a surface due to the wind may be written KSV^2, where S is the area of the surface, V the velocity of the wind, and K assumed a constant in cases where the surfaces are similar and similarly placed, but experiment has shown that K is not a constant where great variations occur in wind velocity. The kinematic viscosity of the air, coupled with some linear dimension of the surface, are the sources to which we must look for this variation. Since we are going to quote the results that have been derived from models, it is necessary to bear in mind the sources of error, as also the advantages and the exactness of the method arising from the employment of a model. The observations are long and laborious, but rapid in comparison with full-scale experiments in the open air, and are more trustworthy, since they eliminate the uncertain factors of weather, motor troubles, and the idiosyncrasies of pilots. The element of personal danger is removed, though the intrepidity of pilots often scorns such small matters. An instance is quoted in which a pilot, who wished to know whether a machine was spirally unstable, took it up to a good height and allowed it to get into a spiral dive. The machine made five turns on a rapidly-winding and contracting helix before a horizontal path could be recovered. The experiment was so far successful that spiral instability was demonstrated, and incidentally the power and adequacy of the controls were established. But it is evident that "no information was obtained as to the degree of instability present, nor as to what particular changes would remedy matters. To complete the experiment it would be necessary to repeat the dangerous feat for every change which suggested itself. Naturally a designer will be very economical in his suggestions under such conditions."

The air conditions in a narrow channel or wind tunnel would differ from those that obtain in the open, but when the object of the research is to show how the motion of an aeroplane is affected by the mutual arrangement of its parts, this consideration is not important. If the machine prove itself unstable in still air, it is evidently more insecure in gusts, though it is possible that an aeroplane may be so stiff that in turbulent air it will be violently tossed about. For the purpose of comparison with the results of similar inquiries it is fortunate that the American wind tunnel and its accessories accurately follows the original four-foot installation of our National Physical Laboratory. This chamber is of square section, and a uniform flow of air is ensured by a four-bladed fan similar to an aeroplane propeller. This propeller draws air at speeds up to 30 miles an hour, and the designers congratulate themselves on securing the steady movement of a large body of air without producing vortices. Each experiment can be repeated under the same conditions of wind action, and the results are strictly comparable.

The experimental model whose behaviour is discussed in detail, and illustrated diagrammatically, was constructed on the lines of a type designed by Captain Clark, who aimed at producing a machine inherently stable, while preserving generally the features of an ordinary Curtiss military aeroplane. A model of this latter has also been under examination, and a comparison of the results, so far as they are given, with those derived from the Clark model are very instructive. The first set of experiments was directed to testing the static stability, a necessary property if dynamic stability is to be secured, and, moreover, the experiments demonstrated a convenient arrangement of the movable parts in the subsequent trials, in which provision had to be made for reasonable righting moments to oppose diving and stalling.

The model was mounted on the balance in the wind tunnel in such a way that the angle of the wind to the wing chord could be varied from + 20 deg. to − 8 deg. The lift, drift and pitching moments were determined at every 2 deg. in each of three positions of the tail. In the first set the tail surface made an angle with the wing chord of − 2.75 deg., and in the second − 7 deg. An intermediate set with the angle at − 5 deg. gave more satisfactory results. The maximum lift and drift in all three cases were the same, but did not correspond to the same angle of attack, showing clearly that changing the angle of tail surface had but a slight effect on the motion and speed of the aeroplane. The statical stability against longitudinal pitching, however, varied very greatly. With the tail inclined at the smallest angle, only small pitching moments were noticeable at ordinary angles of incidence, such as could be easily overcome by the pilot impressing a small diving moment to overcome the observed stalling moment. When, however, the aeroplane was tilted 12 deg. the pitching moment increased, tending to make the machine unstable without the intervention of the horizontal rudder. In the second position of the tail, inclined − 7 deg., the machine is very stable; in fact, too stable, or too stiff longitudinally. The elevator motion available for control in gusty air is largely used up in maintaining balance. In the third case, with the stabiliser held at 5 deg., the longitudinal balance is maintained over a wide range of angle and the natural diving moment is corrected by a moderate negative lift on the elevator. In the subsequent investigations this arrangement of the tail was maintained.

The examination of the longitudinal dynamic stability presents greater difficulties, both in the mechanical devices employed in sifting out the necessary data, and in the subsequent mathematical discussion. The application of the theory of small oscillations of rigid dynamics is laborious, and the determination of the coefficients for use in the equations of motion can only be approximate. Certain terms of small amount have to be neglected in order to keep the equations manageable. The mechanical arrangements for measuring the aerodynamic forces and moments are certainly ingenious, but it is difficult to estimate the percentage of error. Having secured the necessary numerical values for the equations, the results are pursued very thoroughly, both numerically and by graphs. The conditions for stability can be inferred from the sign of the roots of a biquadratic equation, a method that dispenses with the labour of a rigorous solution, but it is necessary to pursue the inquiry further if, as in this case, the degree of stability in varying speeds is needed, or comparison is made between aeroplanes of different design.

The result is to show that when the longitudinal motion is disturbed by wind gusts the aeroplane exhibits an undulatory as well as a pitching motion. The period and character of the undulation are more important, or call for greater watchfulness on the part of the pilot, in low than in high velocities. With speeds of approximately 77, 53 and 45 m.p.h. the periods of undulation in seconds are 34.7, 17.6 and 15.8 seconds, respectively, and these are damped 50 per cent. in 8.1, 11.0 and 13.1 seconds respectively. The damping is seen to be less effective as the flight speed diminishes, and when this is reduced to 37 m.p.h., it is not surprising to find that the flight becomes unstable. The period of oscillation in this last case is 10.5 seconds, but instead of being halved, as in the previous examples, it is doubled in 24.7 seconds. This proof of tendency to instability with diminished speed is one of the salient features of the inquiry, and will not be overlooked by designers. It is unfortunate that comparisons cannot be instituted between a larger number of machines of greater variety of design. but the necessary data increase slowly. The Curtiss machine mentioned above had a natural period of 34 seconds, damped 50 per cent. in 11 seconds, and a Blériot monoplane tested at the National Physical Laboratory by Bairstow had a pitching period of 25 seconds, damped 50 per cent. in 15 seconds. These instances exhaust the published data. Obviously, during the war, whatever information has been collected by belligerents will be withheld. This scarcity emphasises the importance of Dr. Hunsaker's paper.

The investigation of lateral motion follows the same lines as those used in longitudinal. The object is to determine the behaviour of the apparatus under conditions that cause yawing, rolling and side slip. When an aeroplane yaws to the right or left of its course, rolling moments will tend to roll and yaw the machine about the x and z axes, and to give rise to a lateral force at right angles to the longitudinal axis. These forces and moments and all the data for solving the problem can be measured by suitable means on the model in the wind tunnel, under conditions which permit of varying systematically each element of the apparatus that influences the course of flight. The accuracy of some of the measurements is not very great, but fortunately the quantities mainly concerned in the study of lateral stability are those determined with the greatest precision. The effects of the yawing moment, the rolling moment and of the lateral force are each discussed, and very practical conclusions drawn relative to mechanical construction. The curves showing the variation of each are particularly instructive. The diagrams illustrative of yawing show that if the aeroplane yaw to the right a negative yawing moment is produced which tends to turn the aeroplane to the left, favourable to "directional" stability, a quality that may have been overvalued, for its effect may easily be to render the aeroplane unmanageable in gusty air, and, moreover, it is the determining factor in "spiral instability." "Indeed," says Dr. Hunsaker,

* "Dynamical Stability of Aeroplanes," by Jerome C. Hunsaker, Eng.D., Assistant Naval Constructor, U.S. Navy. Assisted by T. H. Huff, D. W. Douglas, H. K. Chow, and V. E. Clark, Captain, U.S. Army. Published by the Smithsonian Institution, 1916.

"directional stability is very nearly incompatible with inherent dynamical stability in roll, yaw and side slip considered together." The rolling moment curves assist to explain the usual rules for banking. In this case the banking moments are positive for a positive yaw, and tend to bank the aeroplane suitably for the turn and to prevent capsizing. The lateral force urges an aeroplane that in still air yaws to the right to be pushed to the right, and the natural banking is again suitable for the turn. From a practical point of view the discussion of the curves indicates the importance of maintaining an effective aileron control to contend against the natural banking tendency, especially when landing. The quantitative determination of stability requires a knowledge of the rates of change or of the partial derivatives of the moments and forces already mentioned. These are determined and made applicable to the full-sized aeroplane. It is sufficient to say that the rates of change with velocity of side slip show no great change with speed, but that the unfavourable effect of a change of the rolling moment on "spiral" stability increases as the speed diminishes. The yawing moment due to rolling increases from zero (with horizontal flight) as the angle of incidence increases, and the sign indicates that for a roll to the right a yaw to the right is assisted.

After considering the causes that promote the damping of roll and yaw and a possible but unlikely connection between longitudinal and lateral motion, the author proceeds to form and solve the biquadratic equation characteristic of lateral motion. By the test of the signs of the roots, already mentioned, it appears that in the particular case of the Clark aeroplane the motion is stable at high and moderate speeds. At low speeds, however, the motion is liable to become unstable, and a similar result was found in the inquiry into longitudinal stability. By the process of factorisation of the biquadratic it is shown that one oscillation, instead of diminishing with time, actually doubles itself in 7.2 seconds. This particular instability can be traced to a "spiral dive," due to overbanking, with a side slip inwards. "The aeroplane starts off on a spiral dive and will spin with greater and greater angular velocity." This motion is known as "spiral instability."

It does not seem possible to decide the relative importance of the operating causes, and in consequence the form mechanical correction should take remains uncertain. An upward dihedral angle of the wings or an increase of the vertical fin surface above the centre of gravity would act advantageously on the rolling moment. Stability can also be improved in other ways that would damp the spin in yaw, but there is always the danger that in reducing one evil another is introduced or exaggerated.

Another of the factors of the biquadratic indicates a type of motion described here as the "Dutch roll," from analogy to a "Dutch roll on skates." It is due to an oscillation in yaw and roll simultaneously. In the model examined it is heavily damped and can never be a cause of dangerous instability, but is a common inconvenience in aeroplanes. The mechanical correction points to the adoption of measures precisely the reverse of those that would diminish spiral instability. The existence of one or other forms is very possible, but it is hardly likely that both forms would exist on the same machine. The examination of the Curtiss model confirms this conclusion. At high speed that machine is spirally unstable, but stable in the "Dutch roll," while at low speed the "Dutch roll" was unstable and the spiral motion was stable. From *a priori* reasoning, the Blériot aeroplane was expected to prove stable in the "Dutch roll," and this anticipation was confirmed, the period of 6.5 seconds being damped to half amplitude in 1.65 seconds. Such a result is eminently satisfactory, but it must be borne in mind that the results deduced in similar discussions from experimental models are only strictly applicable to the model on which the measurements have been made. The conclusions grow in value and interest as a greater number of comparisons becomes possible, and on this ground the aeroplane industry has reason to be grateful to Dr. Hunsaker and his collaborators for the exact detail and information they have supplied.

WOOLWORTH BUILDING, NEW YORK.

By FRANK W. SKINNER, New York.

(*Continued from page 50.*)

Tower Bracing.—The 84 by 86 ft. 55-storey tower, about 800 ft. high above the curb, of which two vertical sections at right angles to each other are given in Figs. 24 and 25, on Plate X, is designed to have independent stability against wind pressure, without considering the resistance of the remainder of the building. The inclined members of the pyramidal roof resist and distribute the wind pressure down to the 50th floor, where it is transferred through floor-beams and gusset-plate connections to the four interior columns that carry it to the 47th floor, where it is again horizontally transferred through the floor construction to the outer columns which, with the wall girders and kneebraces, take all wind stresses down to the 28th floor. Below this there are, on the Broadway front, full deck solid-web single and double plate-girder portals, as shown in Figs. 26 to 32, and on the opposite face of the tower triangular struts, forming trusses of the full depth of the storey, as shown in Fig. 33, Plate X. The maximum direct wind stress compression in a single column of the tower is 2,500,000 lb., plus 200,000 lb. flange stress from the portal bracing.

Portal Bracing.—The maximum computed horizontal wind stress that is resisted by a single system of bracing in the same plane in the same tower is assumed to act on the four Broadway front columns at the first floor level. These columns to the fourth floor level are braced with double plate-girder portals with double 6 by 4-in. flange angles. The vertical portions of the portal webs are from 1 to 3 ft. wide, continuously field-riveted to the projecting plates of the columns. Horizontal portions of the portal web are from 5 to 6 ft. deep, and are spliced with double cover plates to the vertical portions of the webs, both of which are stiffened by flange angles continuous around the curved corners, and by horizontal, vertical and diagonal pairs of web-stiffener angles like those of plate girders. The outstanding flanges of these angles are in many places reinforced by cover plates. The centre panel portals are connected with the side panel portals in the same storey by long and wide horizontal plates extending across both flanges of both portals to form diaphragms between lower and upper sections of the columns, to which they are field-riveted. Each half of the double portals was shipped in four or five sections, field-riveted together with double cover plates. Above the ninth storey the portals are single, with 8 by 8-in. flange angles of a maximum thickness of $1\frac{3}{8}$, and 18-in. top chord reinforced plates in the corner panels to 15 stories.

In the four east and west lines of bracing, perpendicular to the Broadway front (see Figs. 25 and 27, Plate X), each portal is three panels wide, reaching across the full width of the tower and having vertical webs attached to the outside columns only. Up to the fifth floor the portals are double, with 8 by 8-in. flange angles, and above the fifth floor they are single, with 9 by 6-in. flange angles. In one panel the first floor portal is omitted, as shown in Fig. 27, to provide for a two-storey room, and the fourth-storey portal here is made with a wall girder 5 ft. deep and extra wide side plates.

Diagonal Bracing.—Architectural considerations permitted the use of diagonal braces extending the full height of the stories in the west face of the tower below the fourth floor, and these, being cheaper than portal construction, were adopted there. This construction is shown in Fig. 33, Plate X. These braces, which run from the ends of one floor beam to the middle of the floor beam above, are made of two pairs of angles back to back, connected by tie-plates, and shop-riveted at the lower ends to special end sections of the wall girder plates, which project above their top flanges and serve both as connection plates for the braces and as kneebraces for the girders. The upper ends are field-riveted to short special sections of the floor beam webs, which project below the lower flanges. The horizontal struts have 38-in. plate girders in the first and basement floors, and in the second, third and fourth floors are pairs of 15-in. 33-lb. channels back to back.

Kneebraces and Wall Girders.—In the Broadway face of the tower the wall girders from the 28th to the 40th storey inclusive are 3 ft. 9 in. deep, and in the centre panels have deep gusset plates connecting beyond the top and bottom flanges of the girders to form double kneebraces shop-riveted to the columns, field-riveted through double splice plates to the girder webs. The bottom flanges of the girders are field-riveted to the gusset plates through the webs of the latter and through their horizontal shelf angles. This provides convenient support for assembling the girders during erection and makes all the field rivets accessible for easy driving. In the side panels the ends of the wall girders are field-riveted to hitch angles shop-riveted to columns, and instead of gusset plates they are kneebraced to the columns by pairs of channels field-riveted back to back to special end sections of the girder webs, which project beyond the top and bottom flanges near the middles of the girders. The opposite ends of the braces have shop-riveted connection plates field-riveted to the columns. The sections Figs. 34 to 36, and the detail views Figs. 37 to 43, on pages 71 and 72, will explain the system of bracing just described.

At the second floor the wind stresses are transferred horizontally 7 ft. from the upper to the lower set of wall columns through a system of very heavy wall girders, 4 ft. deep, with special end sections projecting 4 ft. beyond the lower flanges to form gusset plates riveted to the columns. From the 43rd to the 46th storey wall girders (see Fig. 38) have a uniform depth of 3 ft. 9 in., and are field-riveted to gusset plates, which project beyond both top and bottom flanges and form end sections of the girder web field-riveted to the main web double cover plates. In the 48th, 49th and 50th floors the gusset plates project beyond the bottom flanges only of the wall girders, as shown in Figs. 37, 42 and 43, on pages 71 and 72.

Floors 50 to 55 of the tower are contained in the pyramidal roof, the construction of which is shown by the vertical sections and elevations, Figs. 44 to 46, and the plans, Figs. 47 to 51, on page 73. These views, with the accompanying details, are self-explanatory.

Steel Erection.—Structural steel was delivered to the water front about 20 miles from the site of the building, where it was sorted, stored and loaded on lighters as requisitioned by the superintendent of the building two or three days in advance of delivery. The lighters transferred to steel trucks, by which it was hauled about a half a mile to the site and delivered in the street or on the working platform at street level, where it was handled by the erection derricks. Shipments were usually made in 300-ton lots up to the first floor and in 500-ton lots above it, and were received about twice a week.

Preparations for erection were commenced while the bottom of the general excavation pit was about 19 ft. above the level of the finished cellar floor and only half of the foundation piers had been completed, with their tops 40 ft. below curb and 3 ft. below ground-water level, accessible through temporary cofferdams 25 to 35 ft. deep. On framed falsework bents installed in the pits there were placed at street level two stiff-leg derricks weighing 35 tons each. They had 35-ft. masts and 50-ft. booms rigged with 12 parts of hoisting tackles of a capacity of 50 tons. These derricks unloaded the trucks in the street and lowered the foundation girders to permanent position. Grillage beams and light girders that were beyond the radius of the derrick booms were handled by gin poles conveniently shifted from point to point.

The girder and column loads were distributed over the full area of the concrete by the grillages, which we have already described and illustrated, consisting of two to four tiers of depp crossed I-beams enclosed in a solid mass of 1 : 2 : 4 concrete made with $\frac{3}{4}$-in. broken stone. The tops of the piers having been roughly finished from 2 to 4 in. below the required elevation of the bottom flanges of the lower tier of grillage beams, provision was made for setting the latter at an exact level on pairs of easily adjusted liners. The liners were horizontal, 2 by 2 by $\frac{1}{4}$-in. angles transverse to the grillage beams

THE WOOLWORTH BUILDING, NEW YO

(For Descriptio see

Fig. 24.
BROADWAY ELEVATION.

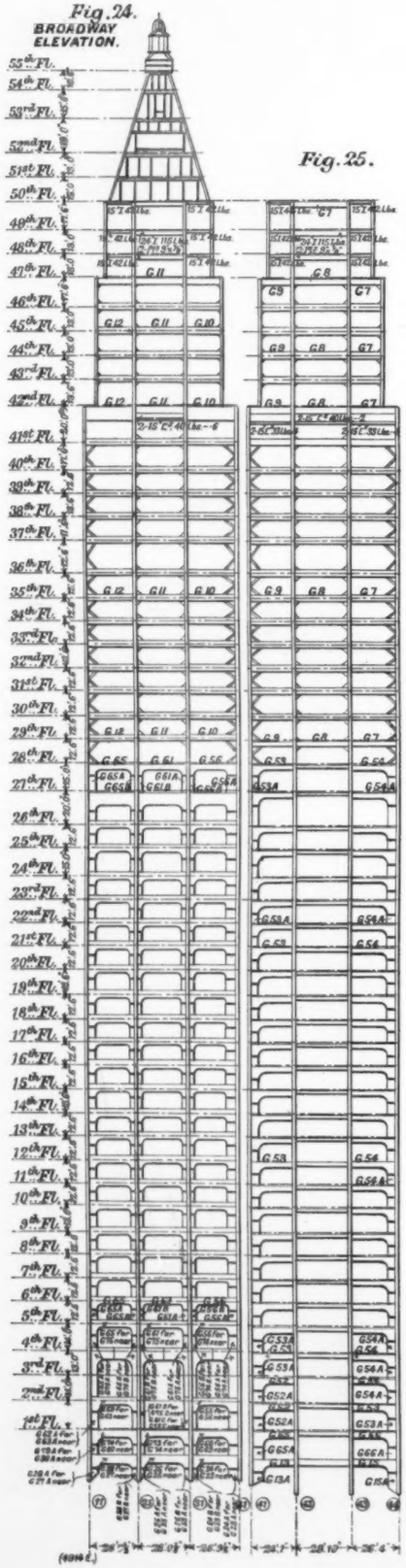
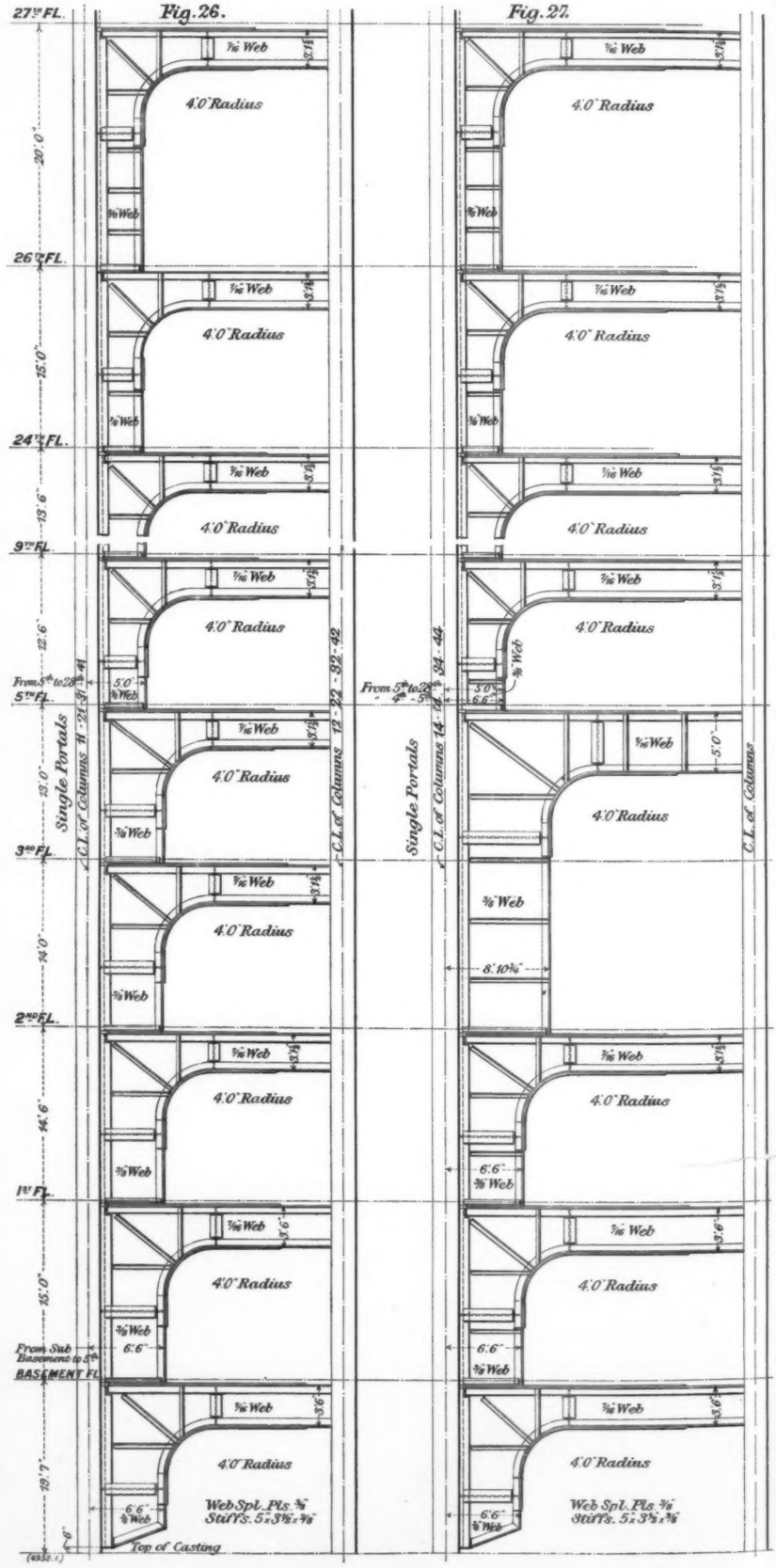


Fig. 25.



EW YORK; DETAILS OF WIND BRACING.

(Description, see Page 70.)

Fig. 28.

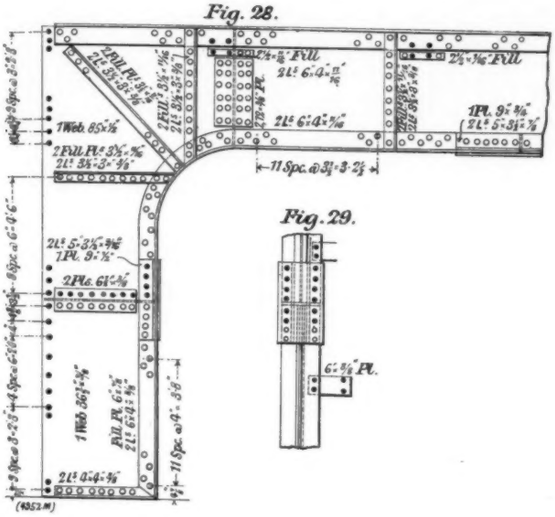


Fig. 29.

Fig. 30.

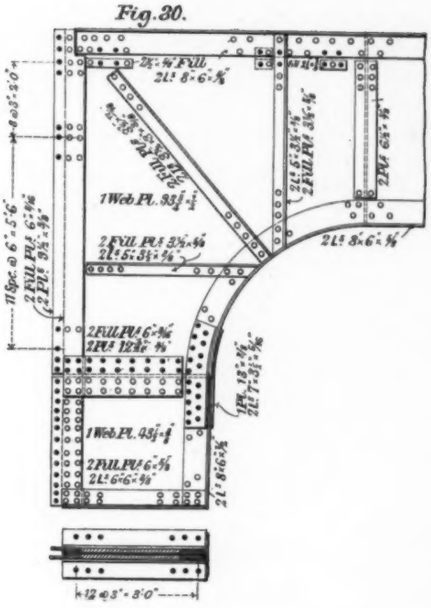


Fig. 31.

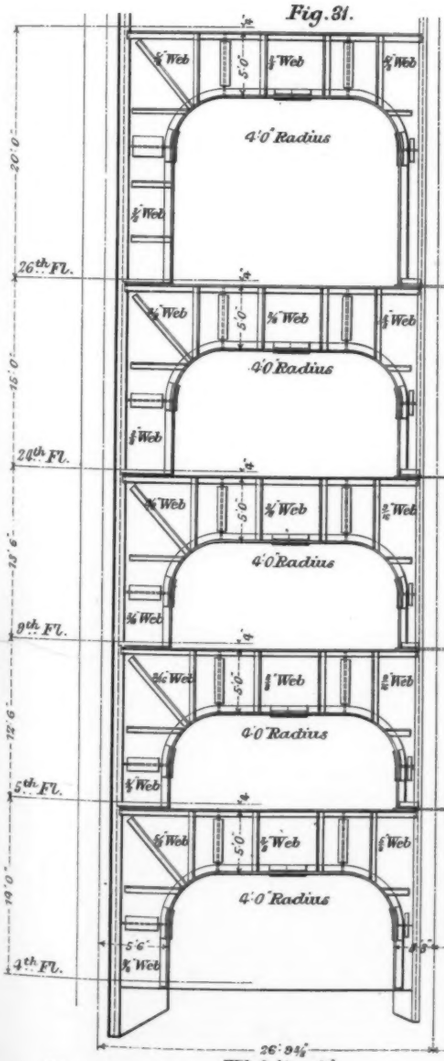
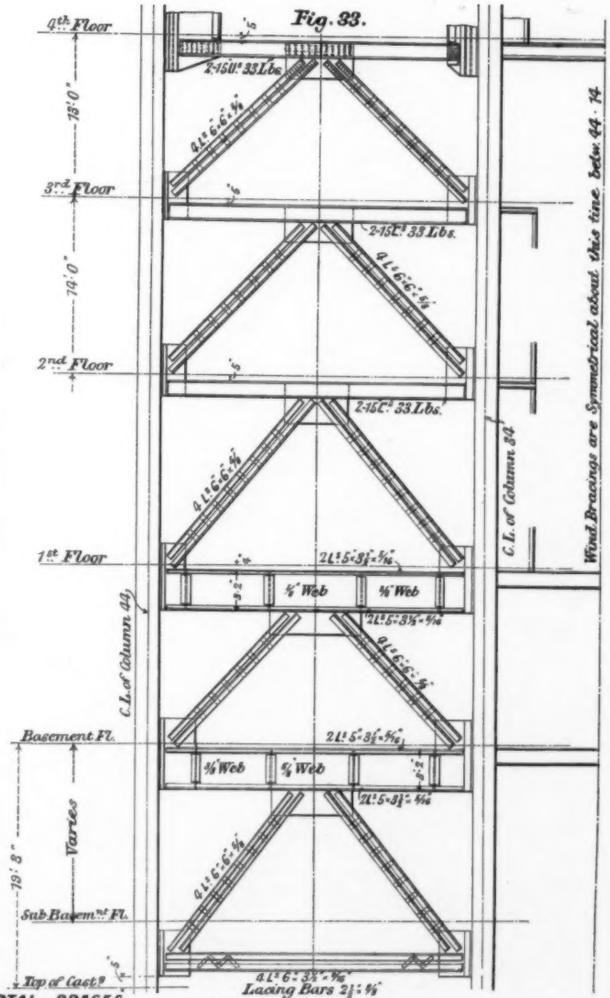


Fig. 32.

Portal Braces Symmetrical about this line.

Fig. 33.



Wind Bracings are Symmetrical about this line, below 4th Floor.

PORTAL BRACES
WEST ELEVATION

THE WOOLWORTH BUILDING, NEW YORK; DETAILS OF WIND BRACING.

Fig. 34.

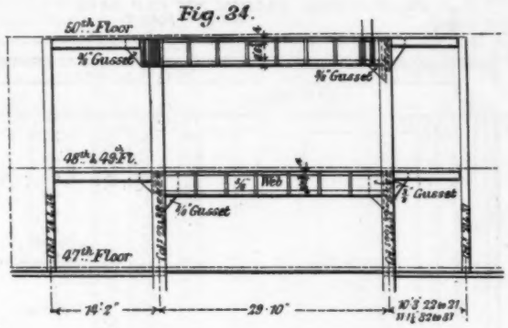


Fig. 35.

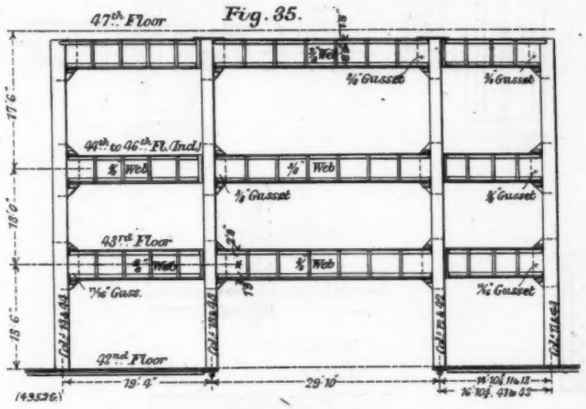
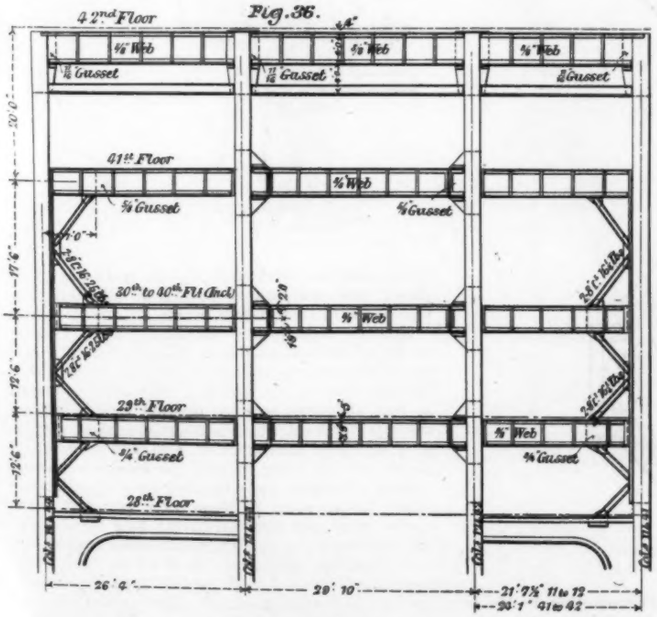


Fig. 36.



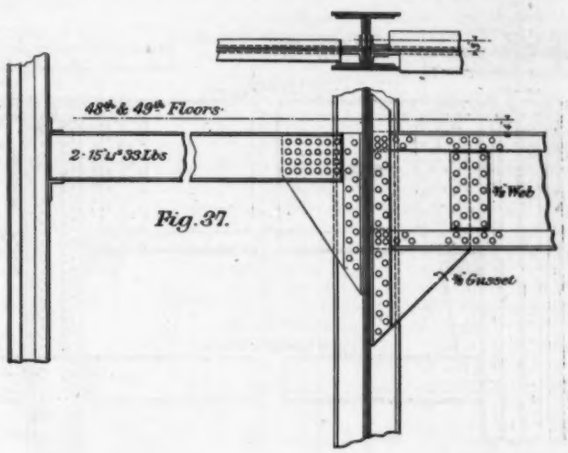
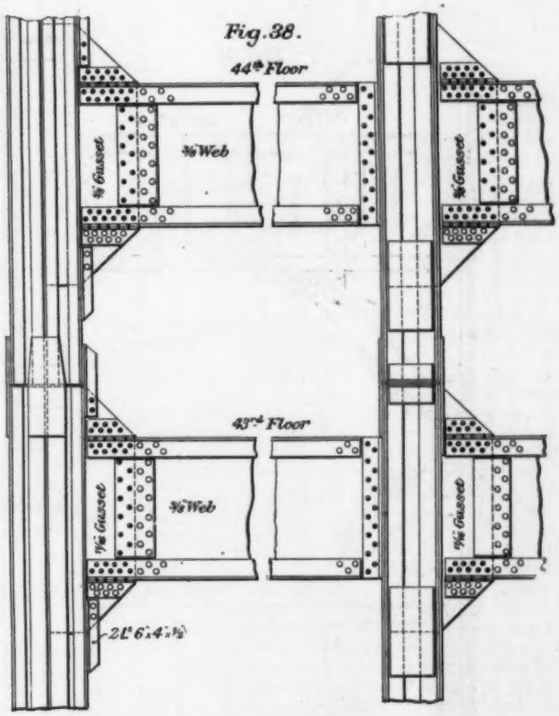


Fig. 37.

Fig. 38.

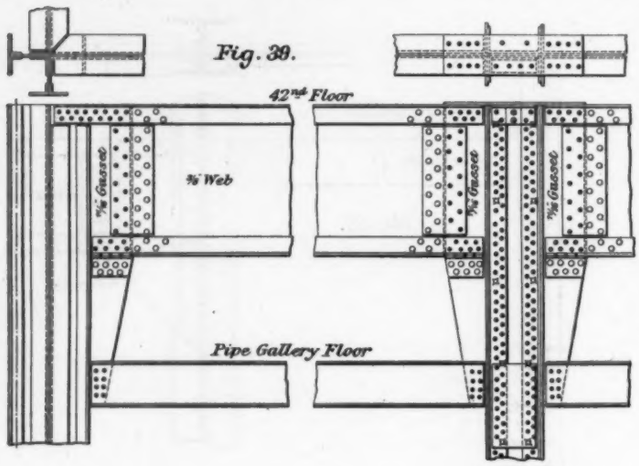


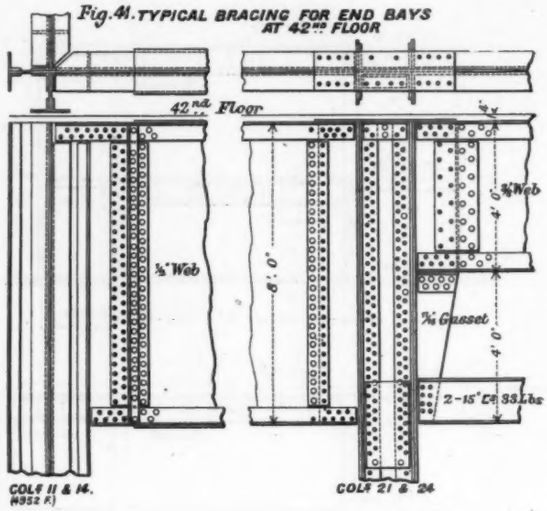
and placed one at each end with the backs up and the flanges at an angle of 45 deg. to the horizontal. They were very carefully levelled to exact position in the same plane, the space under and between them was filled with 1:2:4 Portland cement concrete, the grillage beams were seated on them, and the remainder of the space was filled with one grout. Wooden forms were built up to the top of the grillage enclosing the different tiers of beams, and were filled with soft fine concrete, well rammed between the beam webs.

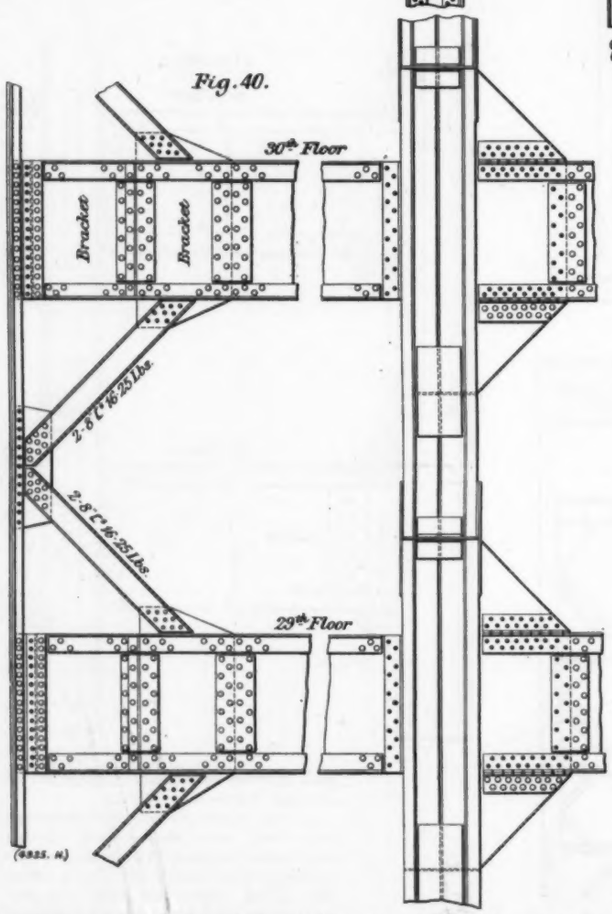
Setting Foundation Girders.—As the deep and heavy foundation girders were supported at opposite ends on separate piers and were set before the general excavation was carried down to the pier tops, it was necessary to connect the pier cofferdams by narrow trenches sheeted down 20 to 30 ft. to the grillage level. Those trenches and the cofferdams were braced, and were put in communication by the cutting away of portions of the pier cofferdams. A view looking down into one of these trenches was given in Fig. 8, on page 56, of our last issue. The transverse braces were removed in successive tiers as the girders were lowered, and in order to resist the heavy lateral pressure were replaced above the girders as the latter descended, thus leaving only short vertical sections of the sheeting unbraced.

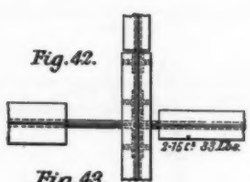
As already described, most of the girders had triple webs and were shop-riveted together, forming single units weighing 25 to 30 tons each, which were lowered to position as received from the birdge shops. The girder connecting piers 41A and 41B has triple webs, reinforced to a total thickness of 4 in., and connected by six sets of transverse diaphragms. It carries a column load of nearly 9,500,000 lb. and is 8 ft. deep and 23 ft. long and weighed 65 tons as shipped complete from the bridge shops. There are seven other tower girders of similar dimensions, all of which were found to be too large to clear the necessary bracing required to insure the safety of the cofferdams enclosing the pier pits and trenches. Therefore in order to avoid enlarging the excavation the webs of seven of these were cut apart on the lighters, and were delivered to the building and lowered into position separately and afterwards field-riveted together in the bottom of the excavation. The first of these eight girders was, however, cut apart at the building site instead of the lighters,

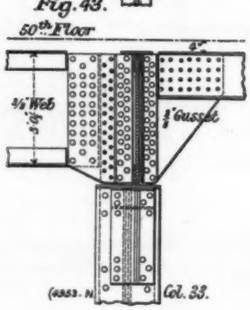
THE WOOLWORTH BUILDING, NEW YORK; DETAILS OF WIND BRACING.











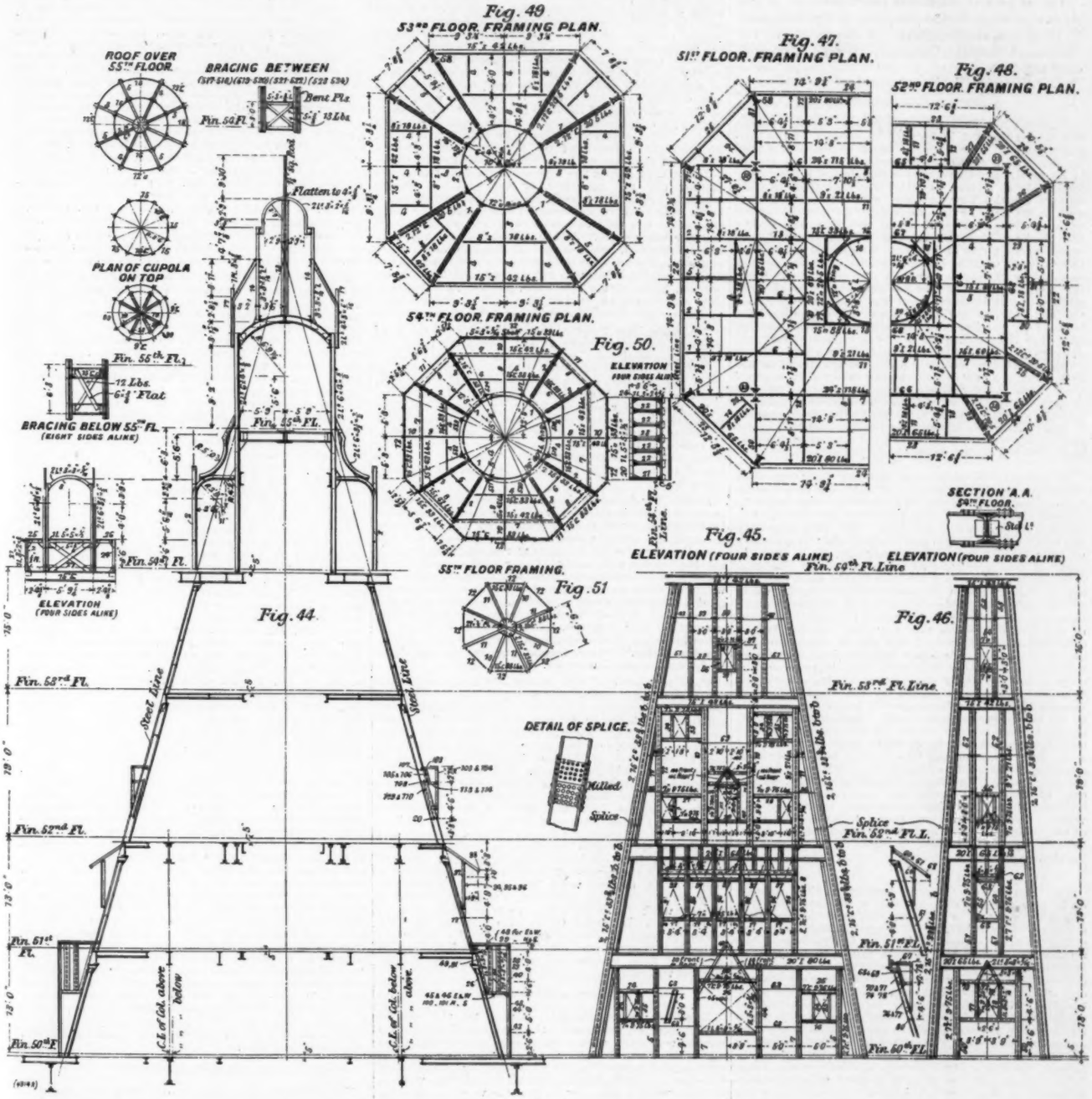
and it required for transportation through the city a 100-ton capacity truck drawn by 42 horses.

Erection of Steel Superstructure.—The stiff-leg derrick that handled the substructure girders installed one wooden stiff-leg derrick and four steel guy derricks, which together commanded the entire area of the lot and the adjacent streets, unloaded the steel from trucks and erected it. The substructure derricks were removed and wall girders and beams were rapidly erected with a force of 30 to 40 men, besides riveters, who, working single eight-hour shifts, in six months erected 19,000 tons of steel, completing the framework up to the 30th storey or main roof level. The framework from the 30th to the 47th storey was erected in a little less than two months. Field-riveting at the rate of 7,000 rivets a day was advanced about two stories behind the erectors, and required about 80 men operating pneumatic hammers driven from a compressor plant in the basement. The riveters were closely followed by the painters and the flooring builders. The best erection record made was that of 1,553 tons of steel placed in six consecutive eight-hour days. The heaviest piece of the superstructure was a column 30 ft. long that weighs 45 tons. This was slung directly to place and seated in position with one movement of the derrick. Wherever practicable the steel work was erected as hoisted, but where this was not feasible it was necessary to hoist it immediately, so as to avoid unnecessarily obstructing the street traffic by the trucks, and the pieces were temporarily stored in piles on the highest tier of erected floor beams.

Erection Adjustments.—Accurate levels taken on all of the column bases showed that in some cases, due to the multiplication of joints between the different tiers of the grillages, they were as much as $\frac{3}{4}$ in. above the required position, or $\frac{1}{4}$ in. above the expected level, which had anticipated an excess of $\frac{1}{2}$ in. This maximum of $\frac{3}{4}$ in was considered negligible. In order to keep the columns exactly vertical they were daily checked by a transit, and about 75 per cent. of them were plumbed with a steel wire rope diagonal having long turnbuckle adjustments. These adjustments were carried up to within two stories of the derricks, and were kept in service until after the field connections had been riveted to a higher level. The lightest columns weigh 11 tons each, and there are some in the 28th storey that weigh 12 tons.

Field Riveting.—About 10 car loads, approximately 200 tons, of rivets were required for the field connections, and were driven with pneumatic hammers operated by air at from 80 to 100 lb. pressure and handled by 22 four-man gangs of riveters, who each averaged 300 1-in., $\frac{7}{8}$-in. and $\frac{3}{4}$-in. rivets in one eight-hour day. Generally the riveters were able to use as working platforms the centring provided for the construction of the tile floor arches, thus saving the expense of constructing special scaffolds. The riveters were preceded by three men with pneumatic reamers, fitting up the

THE WOOLWORTH BUILDING, NEW YORK; DETAILS OF TOWER ROOF.



connection to be riveted. Compressed air for the pneumatic hammers was supplied by two compressors driven by a 25-h.p. electric motor, located in the basement. The compressors were connected to a 150 cub. ft. receiver that delivered through two 3-in. vertical pipes, carried up as the erection progressed and provided at every storey with a manifold, having connections for twelve 50-ft. lengths of ¾-in. wire-bound hose, with 25-ft. extensions of ½-in. rubber hose attached to the hammers.

Steel Derricks.—The steel erection derricks weighed about 15 tons each, and had a 76½-ft. mast guyed by eight 1¼-in. steel ropes 300 ft. long, with turnbuckle adjustments connected to the foundation piers and to the columns. The 66-ft. booms of 30-ton capacity were rigged with an eight-part topping lift and an eight-part hoisting tackle, both rove with ¾-in. plough steel cable. A 12-ton wooden derrick had a 93-ft. mast and an 81-ft. boom of 12-ton capacity. All the derricks were operated by a double drum 80-h.p. electric hoisting engine, which also commanded the horizontal revolution of the booms by swing ropes operated by their spools.

Shifting Derricks.—The derricks commanded and erected two tiers of beams at each position, and in order to facilitate their movement from storey to storey as erection advanced, one floor beam in each storey was omitted in the panel next to the derrick to give room for hoisting the latter. The derrick mast and boom were separated and respectively hoisted each other without rigging the tackles attached to them. The boom was unshipped from the mast, set in vertical position on a temporary foot block, and securely guyed. Its hoisting tackle was then made fast to the mast a little above the centre of gravity of the latter, and the guy lines of the mast were disconnected and their adjusting tackle paid out as the mast was hoisted 25 or 30 ft. by operating the hoisting tackle suspended from the top of the boom. The mast, with its permanent foot block attached, was then lowered to a bearing on a pair of 12 by 16 in. sills, 36 ft. long, to receive it on the floor above and the mast was held in position by the boom acting as a gin pole until its guys were shifted two stories higher, made fast and adjusted by their tackle. The topping lift tackle of the mast was then made fast to the boom at its centre of gravity, the guys on the boom were released, and the mast, acting as a gin pole, hoisted its boom and seated it on the step fastened to the base of the mast, after which the topping lift tackle was attached

by the regular connections at the end of the boom, and the derrick was ready for service again after an interruption of only about six hours.

The structural steelwork was fabricated at the Ambridge shops by the American Bridge Company, C. W. Bryan, chief engineer. It was erected by the Thompson-Starrett Company, George Simpson, chief engineer.

(To be continued.)

SWEDISH NON-PHOSPHORIC IRON ORE.—Some concern has been expressed in Sweden on account of the continued export of iron ore, of which Germany is a keen buyer. The Swedish Government, it has been stated, is giving the matter every attention, but it is practically impossible at present to make any alterations in commercial treaties now in force with foreign countries, and an embargo or an export duty on iron ore, under existing circumstances, is out of the question. One of the leading engineers of the "Järnkontoret" also considers the terms of Sweden's commercial treaty with Germany to contain insurmountable obstacles to any momentary change in Sweden's iron-ore policy. From the point of view of the Swedish producers of high-quality iron it is, however, of the greatest importance that the question of export of iron ores low in phosphorus be carefully watched, and that alterations be considered when the time comes for a new agreement. The real danger of an excessive export of these ores is not so much one of the Swedish deposits being exhausted, but that foreign iron works obtain raw material of superior quality, and thereby become more independent of Swedish quality iron. This is why the Swedish iron industry watches with the greatest attention further developments in this connection, hoping that fresh commercial agreements may contain some guarantee against its chances on the world's market being unduly jeopardised.

A DECIMAL SYSTEM FOR BRITISH COINAGE.—Undoubtedly the decimalisation of our monetary system is the easiest to accomplish of all the reforms proposed by the various societies anxious to revolutionise our existing systems of weights and measures. The florin is already one-tenth of a sovereign, and it would only be necessary to make the ½d. worth one twenty-fifth of the florin in place of one twenty-fourth as at present. The only difficulty lies in the fact that the nation must face any loss that may arise in the course of the reform. When it is a question of reforming other of our weights and measures the politicians and party journalists are able to convince themselves that any such loss will fall on manufacturers and traders, and will be dodged by the nation as a whole. Probably considerations of this kind will have less weight at present than in pre-war conditions, and a circular strongly advocating a reformed coinage has just been issued by the Manchester and District Decimal Association, which has its headquarters at 55, Market-street, Manchester. Among other advantages claimed for the reform is the simplification of book-keeping. Accounts would be kept in florins and cents. only, requiring but two columns instead of three, avoiding the necessity of compound addition in casting up the figures. The latter consideration has, in the case of very large firms, less importance now than hitherto, since mechanical accountants have come into vogue. Such machines are, however, beyond the reach of the ordinary trader, and the proposed reform should have an appreciable effect in diminishing the demand for clerical labour.

THE FUTURE OF GERMAN SHIPPING.—The question as to how German shipping will be situated after the war and how it is to be dealt with is attracting much attention in Germany, and a recent prohibition against selling German shipping shares to foreign buyers has further emphasised the interest taken in the matter. Divergent views prevail as to whether Germany, with the residue of her merchant navy still under her control, and which is estimated at some two-thirds of the peace tonnage, will enter promptly into full international competition. No doubt, however, seems to exist as to the necessity of dealing extremely economically with the remaining tonnage. The shipping circles themselves are stated to be realising this necessity. Strangely enough, the first impetus towards legal restrictions seems to have emanated from Hamburg, which shipping centre hitherto has been very independent and confident; the motives for this move do not yet appear quite clear. Some of the strongest anti-subvention concerns in the past now hint at, or clamour for, Imperial subsidies to support German owners in the competition against foreign rivals, in a similar way to that followed in other countries. Large sums have been mentioned in this connection, so far, however, without meeting with any Imperial response. The freedom of German shipping, on the other hand, has been curtailed, or some might call it "protected," through several legislative restrictions. These refer to certain limitations in the matter of chartering where foreigners are concerned, to an indirect prohibition upon the shipyards to accept contracts from abroad, to the sale of German tonnage to foreigners, and, lastly, to the sale of German shipping shares to foreigners. The existing chartering limitations are, in some quarters, considered inefficient; there are apprehensions lest tonnage will be very difficult to obtain for carrying the large quantities of various commodities needed after the war, and it has been suggested that the Imperial Commissioner should be empowered to interfere, during the transition period, in the matter of chartering.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Steelmaking in the West of Scotland goes on apace, the condition of ceaseless activity being a marked feature and the demands of our own and the Allied Governments so very insistent that the utmost pressure for delivery continues to exist, despite the united efforts of masters and men. Great things are expected from the new smelting furnaces, which should shortly be in a position to provide a much better supply of semi-finished material for the local rolling mills. A new development has now to be reckoned with, since, under the direction of the Ship Controller (Sir Joseph P. Maclay), a considerable quantity of steel will be required for the new steamers which are to be built on the Clyde. Through the influence of the Ship Controller quite a number of these vessels have been allocated to the Clyde yards, and to supply the necessary amount of steel will further tax the resources of the makers. Export business, owing to the stringency of the restrictions, is being reduced to a minimum, France and Italy being practically the only countries to which any shipments are now being made. At the moment, export rates are merely nominal, while home maximum prices remain almost unaltered—the quotations for steel ship plates may be anything between 14*l.* 12*s.* 6*d.* and 14*l.* 17*s.* 6*d.* per ton, boiler plates about 20*s.* per ton in advance of this, and angles about 14*l.* 15*s.*—all of these subject to some slight alteration as occasion demands.

Malleable Iron Tade.—Like every other branch of industry depending more or less intimately upon war work, the malleable iron trade continues to flourish amazingly, makers asserting with confidence that in every instance the plant is running to its fullest capacity. Licences for exportation are not required, so heavy is the demand for material for war purposes that there is practically nothing available for ordinary mercantile consumption after this demand has been satisfied—if, indeed, it be possible to satisfy it at all. While the home rates remain unchanged, "Crown" bars for export are quoted 14*l.* 12*s.* 6*d.* to 14*l.* 15*s.* per ton f.o.b. Glasgow.

Scotch Pig-Iron Trade.—As matters stand at the moment there is practically nothing new to chronicle in connection with the pig-iron trade, so great is the demand for every quality, and particularly for the hematite required by the steel works, that the furnaces are kept going constantly. Order books are full, and makers find considerable difficulty in coping with the wants of their numerous customers, forge and foundry grades being also much in request. It seems more and more evident that all the supplies available must be earmarked for war purposes, to the total exclusion of all other branches of business, even export being meantime "a dead letter." Rates remain much on the same level as during the past few weeks.

Tube Workers and War Bonus.—In connection with the negotiations which have recently been in progress between the employers and the workers engaged in the tube-making industry in the West of Scotland, the appointment, by the Board of Trade, of Sir Thomas Munro to act as arbiter, was received with much satisfaction, and in pursuance of this appointment he presided at a conference held in Glasgow on January 12. The agreement regarding the war bonus to be conceded to the workers was drawn up between Mr. Owen Coyle, representing the Iron and Steel Workers' Society; Mr. Robt. Climie, representing the Workers' Union; and representatives of the firms of Messrs. Stewarts and Lloyds and the Scottish Tube Company; and Sir Thomas Munro has just confirmed this agreement. By the provisions of the agreement, it has been arranged that a bonus of 1*s.* 6*d.* per week be granted to lads under 18 years of age and to all men over that age a bonus of 3*s.* per week, these payments to take effect as from January 20. In order to avoid complications with arrears it has been decided that for the first six weeks after the agreement came into force a double bonus should be paid. It is satisfactory to note that the women workers will also benefit very materially.

BUSINESS WITH RUSSIA.—Owing to the special importance, at the present time, of establishing commercial connections, on a firm basis, between the allied countries, with the object of ousting German intervention and competition, the Russo-British Chamber of Commerce at Petrograd requests all British firms wishing to trade with Russia now or after the war to send their catalogues and price lists (not less than 10 copies) to the Chamber. The catalogues in question will be placed in the special library of the Chamber, and will be distributed to Russian merchants interested in the development of their trade connections with England. They are to be addressed to the Russo-British Chamber of Commerce, 4, Gorochovaia, Petrograd, Russia.

THE RISE IN PRICES OF BUILDING MATERIAL.—A Danish authority states that bricks are 65 per cent. dearer, cement and timber 100 per cent., iron for ferro-concrete 300 to 400 per cent., &c. The stocks of steel girders have vanished entirely, and the same applies to Monier iron bars. As a result it has been impossible to complete several half-finished buildings. This is all the more awkward on account of the large number of foreigners who, for diverse reasons, have taken up their abode in a number of neutral cities, the result being a perfect house famine. This applies, for instance, to the three Scandinavian capitals, where there literally are no houses or apartments available, and where the authorities have had to provide shelter for houseless families.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The chief difficulty is one of supplies. In all branches there are very heavy demands, but the tonnage arriving does not permit of much business outside contracts. Manufacturing fuels, in particular, are strongly held, for munition works, blast-furnaces, and railways are large consumers. Their endeavours to build up stocks depleted during colliery holiday stoppages are not meeting with much success. Steam hards are the most sought after, both by home traders and shippers, and supplies barely meet requirements. Cobbles appear a little easier, but steam nuts are again upon a limited scale, and there is a shortage in certain quarters. Gas companies are anxious for the maximum tonnage, which leaves little surplus for shipment. Severe wintry weather has increased the volume of business in the house coal departments. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton.

Iron and Steel.—There is no prospect of a diminution of the demands for all classes of Sheffield goods, but, on the contrary, there are many indications that in the near future the production will have to be again progressively enlarged. The greatest increase of business which is noted during the period of 1917 up to date is in connection with shipbuilding material and equipment. Sheffield firms, particularly Messrs. John Brown and Co., Messrs. Vickers, and Messrs. Cammell, Laird and Co., have substantial orders in hand, due to the speeding-up in delivery of merchant tonnage. This prosperity is expected to continue long after the war, for the need for merchant ships will, in all likelihood, be as great then as now, though the demand may not be so urgent. Sheffield firms, of course, expect a full share of any such development, a reasonable assumption in view of the manner in which several of them are linked up with shipbuilding enterprises at Clydebank, Birkenhead, Barrow, and elsewhere. All steel firms continue upon full production. The difficulty is not in finding the market for output, but in meeting Government and other requirements. This condition is reflected in the greater activity now apparent in the metal market. All brands share in the increased business, and were it not for the Government regulation price list, it is conceivable that the phenomenal rises of the earlier days of the war would be repeated. As it is, the changes are small and of little significance. West Coast hematites remain at 127*s.* 6*d.*, and East Coast, 122*s.* 6*d.*, with delivery at works. Other prices are:—Lincolnshire foundry, 97*s.*; Derbyshire forge, 92*s.* 6*d*; and foundry, 94*s.* to 94*s.* 6*d.* South Yorkshire "Crown" bars change hands at 13*l.* 15*s.*, and hoops, 17*l.* 2*s.* 6*d.* to 18*l.* 2*s.* 6*d.* Light foundries have not an abundance of orders, though there is no present slackness. One of the busiest branches is that of the agricultural engineer. Orders abound, but there seems very small chance of them all being executed in time for the spring season. Municipalities, as well as individuals and joint bodies, are among the customers, and it will go ill with any who have delayed handing out their contracts. Works are handicapped by shortage of men and inability to secure full supplies of steel. The Admiralty are inviting Sheffield tenders for 12,000 table knives, and smaller quantities of other cutlery. For the Army, the requirements are 10,000 flaying knives, 10,000 cooks' forks, 20,000 nickel silver forks, 30,000 nickel silver spoons, 12,000 plated spoons, 6,000 digging forks, 5,000 hammers, and substantial quantities of joiners' and edge tools. Government contracts have just recently been placed for tools, wire, barrow wheels, clasp knives, razors, and surgical instruments. The restrictions of the Ministry of Munitions with regard to the supply of steel to the cutlery trade, and copper to the silver and plate makers, have been discussed at length in these notes, and it only remains to be stated that official intimation has been received that the Government has no desire to cripple such valuable industries. Nothing definite has been heard as to how such a result will be avoided, but there is a distinct feeling of hopefulness in the trades concerned. Overseas business is for files, saws, tools, hammers, plane irons, machinery parts, hardware, sheep shears, cutlery, plate, wire and steel.

THE ELECTRIC RESISTANCE OF SELENIUM CELLS.—According to Professor H. Greinacher, of Zürich, selenium cells of the original Shelford Bedwell type, which he studied together with Mr. C. W. Miller, behave with respect to alternating currents as they behave when exposed to light, and show polarity when traversed by continuous currents. Communicating his observations to the German Physical Society ("Verhandlungen, 1916," pages 107 to 134) Greinacher stated that the resistance of the selenium cell rose when direct current flowed in the dark, that this increase in resistance was different for positive and for negative currents and increased with the time, and that selenium cells acted in a certain sense like current rectifiers. These statements are questioned (*Ibid*, page 184) by Dr. Robert Fürstenau, of Berlin, who, in experimenting with hundreds of selenium cells with similar bridge arrangements as Greinacher, had never noticed any of these effects. Fürstenau suggests that Greinacher's cells had been of peculiar kind. That selenium cells are very sensitive to moisture, and that the electrode material may have peculiar puzzling effects, is fairly well understood, and these features may explain some of the controversial statements made from time to time.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Home consumers of Cleveland pig-iron have made arrangements for deliveries to cover their requirements, and for the time being are not in the market to buy, but there are heavier inquiries from Scotland, and demand from abroad is considerable, neutral countries, as well as our Allies, being anxious to place orders. There has been an offer in the market this week to pay 107*s.* for Middlesbrough warrant iron for export, but for what destination is not ascertainable. A moderate new export business is passing, but with arrears of shipments still to clear up, licences for export of recent sales are still only sparingly issued. For home consumption No. 3 and No. 4 foundry, and No. 4 forge all stand at 87*s.* 6*d.*, and No. 1 is 91*s.* 6*d.*; whilst for despatch to our Allies No. 3 is 97*s.* 6*d.* to 98*s.*; No. 4 foundry, 96*s.* 6*d.*; No. 4 forge, 95*s.* 6*d.*; and No. 1, 102*s.* 6*d.*; and for shipment to neutral countries the minimum prices named are 105*s.* for No. 3 and 110*s.* for No. 1.

Hematite Iron.—The East Coast hematite branch of trade presents few new features of moment. Home consumers experience no difficulty in satisfying all their legitimate needs, and are receiving regular and ample supplies on running contracts, whilst fair quantities are now available for export, and further sales to Italy are reported. Licences for shipment of recent sales, however, are still difficult to secure, because of considerable cargoes yet to be despatched in fulfilment of contracts made some little time ago. Prices are steady and firm. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, 137*s.* 6*d.* for shipment to France, and 142*s.* 6*d.* for export to Italy.

Stocks and Shipments of Pig-Iron.—Some of the makers have recently accumulated a little stock of pig-iron at their yards, but it promises to be quickly absorbed in the very near future. The stock of Cleveland pig in the public warrant stores still stands at 3,498 tons, composed of 3,462 tons of No. 3 quality and 36 tons of other kinds of iron deliverable as standard, no change having been recorded since the 16th inst. Since the beginning of the month the stock has been reduced by the withdrawal of 240 tons of No. 3. Recent persistent bad weather has delayed shipments, but the despatches are now showing improvement, and January clearances promise to be on a satisfactory scale. So far this month the loadings of pig-iron at Middlesbrough amount to 20,904 tons, as compared with 25,205 tons to the same date last month, and 24,981 tons for the corresponding part of January last year.

Coke.—The demand for coke for local use is large, and promises to be heavier. Consumers do not hesitate to pay the fixed maximums that have ruled for some time past. Thus, average blast-furnace kinds rather readily realise 28*s.* at the ovens, and 30*s.* 6*d.* at the ovens rules for qualities low in phosphorus.

Foreign Ore.—Imports of foreign ore are on a fairly satisfactory scale. Large arrivals are expected during the next few days, so that the total imports for January should be quite up to expectation. To date this month the unloadings at Middlesbrough amount to 149,579 tons.

Manufactured Iron and Steel.—Manufacturers of finished iron and steel are working at full pressure, and have well-filled order-books, and it is gratifying to be able to report that, despite the pressure for delivery of other descriptions, production of mercantile shipbuilding material is large and increasing. Prices, all round, are very strong. The following are among the principal market quotations to home customers:—Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 17*l.* 10*s.* to 18*l.* 10*s.*; packing iron and steel (parallel), 12*l.*; packing iron and steel (tapered), 14*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 19*l.* to 20*l.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

BENZOL FOR MOTORS.—Many of the more important gas and colliery undertakings which have installed benzol-recovery plant for meeting the urgent demands for war purposes have been approached by representatives of the motor industry as to their probable future production of benzol. Benzol is recoverable to the extent of about 1 to 1¼ gallons per ton of coal carbonised in the process of coal gas manufacture, and future supplies may largely depend upon a sufficient outlet for the resultant coke (about 11 cwt. per ton of coal carbonised) being obtained. In the past surplus coke has been extensively used in the manufacture of carburetted water gas, which contains little or no benzol, and, moreover, is dependent upon imported solar oil—now much enhanced in price owing to shortage of tank tonnage. It will, therefore, be seen that while it is to the national advantage, and also to the interest of both the gas and the motor industries, to minimise, so far as possible, the use of imported fuels, it is incumbent upon the motor interest, which desires to see abundant supplies of benzol, to assist by making the fullest possible use of the residual fuel, gas coke. The extent to which benzol production might reach is indicated by the fact that one large gas company last year carbonised nearly 1,800,000 tons of coal, and that the gas made from even this large quantity was supplemented by the addition of carburetted water gas, the manufacture of which involved the use of about 13,250,000 gallons of imported oil.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The general tendency of the coal market has been somewhat easier. Tonnage has arrived, and loading has been proceeding with activity, although the uneasiness in regard to shipping, to which we referred last week, remains practically unaltered. In the meantime the stocks of coal have accumulated. In the matter of steam coal, best Admiralty large and best seconds remaining nominal, the last quotations f.o.b. which have come to hand are the following:—Secondary quality, 28*s.* to 29*s.*; ordinary, 25*s.* to 27*s.*; Monmouthshire Black Veins, 28*s.* to 29*s.*; Western Valleys, 27*s.* to 28*s.*; Eastern Valleys, 25*s.* to 26*s.*; best bunker smalls, 17*s.* to 19*s.*; cargo smalls, 12*s.* to 16*s.* In regard to bituminous coal, best households at pit have made 25*s.* 6*d.* to 26*s.* 6*d.*; No. 3 Rhondda large, 28*s.* to 29*s.*; No. 2 Rhondda large, 24*s.* to 25*s.*; and No. 2 smalls, 15*s.* to 17*s.* Patent fuel was quoted 35*s.* to 37*s.*, and coke for export made 62*s.* 6*d.* to 65*s.* for special foundry; 57*s.* 6*d.* to 60*s.* for good foundry; and 47*s.* 6*d.* to 52*s.* 6*d.* for furnace coke. The latest quotations for pitwood ex-ship were 58*s.* to 60*s.*

Western Trade Matters.—At a meeting of the directors of the Anglo-Spanish Coaling Company, Limited, held last Monday at the Cardiff Docks, Mr. J. P. Cadogan was elected chairman in the place of Lord Rhondda, who resigned following upon his appointment to the Ministry.—The annual meeting of the South Wales and Monmouthshire Coal Freighters' Association was held a few days ago, when Mr. F. B. Saunders, the commercial manager of the Rhymney Company, was elected chairman for the year, in succession to Mr. T. J. Callaghan.—Last Monday a meeting took place of Cardiff shipbrokers and chartering representatives, with the object of considering a scheme for the formation of a Cardiff Shipbrokers' Association to protect the shipbrokers' interests. The position of shipbrokers in relation to the new Government proposals with reference to the chartering of foreign tonnage was also considered at the meeting.

SAFETY IN RAILWAY TRAVELLING.—In 1916 the Pennsylvania Railroad System carried in its trains more people than in any previous year of its history, and did so without losing the life of a single passenger in a train accident of any kind. Statistics which have just been compiled show that during the year there were trans ported safely, on the lines east and west of Pittsburg, 196,294,146 passengers. Figures for the last few weeks of the year are necessarily partly estimated. The heaviest freight traffic ever handled by the Pennsylvania Railroad system was moved over its lines at the same time that these passengers were being carried without loss of life. The entire Pennsylvania Railroad system, taking into account every affiliated company either east or west of Pittsburg, now has to its credit three full calendar years in which no passenger has been killed as a result of a train accident on any portion of the lines. During this period 553,890,063 passengers—equal to five and one-half times the population of the United States—have been safely transported a total distance of approximately fifteen billions of miles, or 150 times as far as the sun is from the earth. Upward of 9,000,000 trains, carrying both passengers and freight, were operated by day and night, through sleet and storm, and fog and sunshine, over 12,000 miles of railroad line and 27,000 miles of track, while these passengers were being taken on their journeys without loss of life.

PROJECTILES FOR THE UNITED STATES NAVY.—In the proposals which were opened on the 3rd inst., which cover 7,200 sixteen-inch armour-piercing, 8,100 fourteen-inch armour-piercing, and 900 fourteen-inch, Class B (non-armour-piercing) projectiles, were as follow, says the *Iron Age*:—16-*in. A.P.*:—Bethlehem Steel Company, 4,000 at $775 each; first delivery in 22 months, and one lot each two months thereafter. Crucible Steel Company of America, 1,700 at $768.50 each; deliveries to begin in 760 days, and continue at the rate of 500 every 105 days. Midvale Steel Company, 1,000 at $900 each; deliveries to begin in 600 days, and to continue at the rate of 500 every four months thereafter. Washington Steel and Ordnance Company, 2,500 at $750 each; deliveries to begin in 20 months, and to continue at the rate of 165 per month. Hadfields, Ltd., 3,000 at $513 each; deliveries to commence in 11 months, and to continue at the rate of 500 per month. 14-*in. A.P.*:—Crucible Steel Company, 2,000 at $543.50 each; deliveries to begin in 1,076 days, and to continue at the rate of 500 every 60 days. Midvale Steel Company, 5,600 at $550 each; deliveries to begin in 450 days, and to continue at the rate of 500 each six weeks thereafter. Washington Steel and Ordnance Company, 1,000 at $500 each; deliveries to begin in 20 months, and to continue at the rate of 250 per month. Hadfields, Ltd., 4,500 at $356 each; deliveries to begin in 11 months, and to continue at the rate of 500 per month. 14-*in., Class B.*:—Bethlehem Steel Company, 900 at $310 each, all to be delivered within 22 months. We may add that Messrs. Hadfield's offer has been accepted; but the official announcement is made that the Minister of Munitions desires it to be known that the whole output of steel in the United Kingdom is under his control, and that, so long as the exigencies of the war continue, no permission will be, or can be, given by him to proceed with this work, seeing that it would involve the employment of men and the use of materials for purposes other than those necessary for meeting the needs of ourselves and of our Allies. The Minister understands that Messrs. Hadfield, when tendering, stated clearly that their offer was conditional upon permission being obtained to manufacture the shells.

CAST-IRON: WITH SPECIAL REFERENCE TO ENGINE CYLINDERS.*

By J. EDGAR HURST, Manchester.

(*Concluded from page* 54.)

FIGS. 19 and 20, page 76, illustrate the swelling out of the graphite and the partial liquation of the phosphide eutectic, and are supplementary to Fig. 18 on page 53 *ante*. The specimen was cut from a high phosphorus cast-iron bar heated to 890 deg. C. for a protracted period. The distinctly granular appearance of the pearlite is a characteristic feature of the heat-treated cast-irons. The lamellar character of the pearlite is rapidly lost, and changes into either a bead-like or granular form, according to the temperature maintained during heat treatment and the rate of cooling of the specimen.

SECTION 3.—ON CHEMICAL CONSTITUTION.

The question of the most suitable chemical composition for cylinders, liners and pistons is a most important one, and involves an immense number of considerations which increase the complexity of the subject enormously.

Primarily, the properties required of cast-iron for the manufacture of engine cylinders, liners and pistons are—

(1) Resistance to wear and maximum running properties.

(2) Highest tensile strength and mechanical properties.

(3) Resistance to growth and cracking when subjected to the high temperatures, such as are attained in Diesel engine cylinders.

It will already have been appreciated, and it is undoubtedly a very fortunate circumstance, that the highest mechanical strength and good wearing properties in cast-iron are practically synonymous terms. This statement is to be qualified, however, by the effects of surface flow and allied phenomena.

The presence of certain elements in notable quantity, particularly the element manganese, undoubtedly has a large influence on the wearing and running properties combined. This influence is largely due to their influence in the production of glazy surfaces. High-manganese cast-iron more readily presents a glazy surface in an engine cylinder after use than low-manganese irons. The element chromium is even more valuable in this respect.

The mechanical strength of cast-iron rapidly falls with increasing temperatures. This is an important consideration in connection with surface disintegration, and it is very probable that the influence of manganese and chromium in increasing the resistance to wear, more particularly by surface disintegration, can be traced in some degree to their influence in the production of higher strength irons at high temperatures. Unfortunately as yet we have no figures to confirm this view.

The following table (Table IV) shows the influence of temperature on the mechanical properties of cast-iron (8).

TABLE IV.

Temperature, Deg. C.	Bending Strength.	Inches. Bend.
	Tons per sq. in.	
18	23.53	0.31
66	22.22	0.30
268	21.08	0.28
297	19.88	0.30
620	12.09	0.55
807	7.56	0.94
18	23.58	0.30
85	21.90	0.28
155	21.27	0.28
370	21.02	0.30
580	16.03	0.57
810	6.16	0.79

Mechanical Properties.—The mechanical strength properties of cast-iron depend almost entirely, under normal conditions, on the state of the carbon and the grain size. In their turn these two factors are entirely controlled by the chemical constitution of the iron and the thermal treatment (by which is understood the casting temperature and the rate of cooling) of the iron.

It must always be borne in mind in mechanical strength considerations of a heterogeneous alloy, such as cast-iron, that the arrangement and distribution of the constituents are quite equal in importance to the quantity.

The most important factor in the chemical constitution is the silicon content. The average conception of the influence of silicon in cast-iron does not appear to be quite correct. The researches of Dr. Hatfield (9), Charpy and Grenet (10), and others show that the influence of silicon is inseparable from that of the rate of cooling. In Dr. Hatfield's experiments it was shown that the precipitation of free carbon does not occur with increasing silicon content in a gradual manner, as generally conceived; but there would appear to be a silicon percentage—in this worker's case, between 1.4 per cent. and 1.7 per cent.—at which the complete dissociation (for practical purposes) of the carbide and the precipitation of the free carbon is brought about. The amount or concentration of silicon necessary to bring about dissociation depends upon the rate of cooling.

This is substantiated by Hague and Turner (11), who point out the ease with which the metastable conditions in the presence of silicon revert to the stable conditions, and *vice versa*. In their experiments on the iron-carbon silicon alloys, at the white-iron end of the series, slow cooling of the metal in the crucible, even with so low a silicon content as 0.03, left the metal quite grey, whilst,

* Paper read before the Manchester Association of Engineers, on Saturday, December 9, 1916.

on the other hand, the slight chilling effect of a small platinum pin in connection with their extensometer instrument, embedded in the test bar castings and mould, was sufficient in certain bars to produce a local white fracture whilst the rest of the casting was quite grey.

The importance of this is that it is approximately in the region of this point—*i.e.*, the point at which the silicon percentage, coupled with the rate of cooling, brings about the dissociation of the carbide content, producing a "completely grey bar"—that the closest grained finely divided graphite irons are obtained, with consequently high mechanical properties. This is amply shown by the examination of specimens from the boundaries of the chilled and grey portions of chilled test bars. In such specimens the conditions of a constant silicon content with a gradually decreasing rate of cooling from the chilled edge inwards obtain. The portion at the boundary of the chilled and grey portion is that at which the rate of cooling is just sufficient to bring about the dissociation of the carbon content, which, it will be seen from the microphotograph, Fig. 21, is inaugurated at numerous centres, and develops in this particular instance to a completely grey iron having a network arrangement of the phosphide, together with very finely divided, oft-times rosette-formed, graphite.

The author would emphasise the advisability of employing a much lower silicon content than is usually the case in actual present-day practice. The analyses given in the following table serve to illustrate this point. These analyses are taken from gas-engine liners of very closely related cross-sectional area, and illustrate admirably the apparent inutility of, in this case, the excess silicon content over approximately 1 per cent. There should be no difficulty experienced in the production of low-silicon content cast-irons. These are readily produced by the addition of varying proportions of either steel scrap or white irons to the cupola mixture. It should be pointed out that this is the only real advantage of the so-called semi-steel mixtures.

In these low-silicon irons the presence of those elements having a great influence in increasing the stability of the carbide, such as sulphur, must be kept at a minimum. In the analyses in Table V it will be seen that the presence of 1 per cent. of manganese in these low-silicon irons still leaves the iron quite grey.

TABLE V.

Sample No.	Analyses.						Thickness of Casting.	Brinell No.
	CC. per cent.	Gr. per cent.	Si per cent.	Mn per cent.	S per cent.	P per cent.		
1	0.61	2.70	1.23	0.85	0.072	0.93	¾	228
2	0.68	2.68	0.93	1.04	0.080	1.18	1	228
3	0.87	2.46	0.98	1.10	0.090	0.89	1¼	228
4	0.64	2.38	2.04	0.84	0.069	0.702	¾	196

Unlike manganese, small percentages of chromium favour the retention of the carbide, and consequently, in such low-silicon irons chromium must not be present in excessive amounts.

The influence of casting temperature has already been indicated in Table I (page 53 *ante*). Broadly speaking, the higher casting temperatures favour the retention of the carbide. This is in all probability due to the phenomenon of under-cooling (12). The metastable carbide phase is retained beyond its true dissociation temperature. The influence of casting temperature is more pronounced in the case of low-silicon irons, as, for instance, the case recorded by Dr. Hatfield (13), in which two bars of the following composition were cast, the casting temperatures of the two bars being varied by 180 deg. C. The higher casting temperature bar presented a mottled white fracture, whilst the other bar was quite grey.

	Per cent.
Total C	3.20
Si	1.10
Mn	8.41
S	0.62
P	0.20

The necessity for controlling and standardising the casting temperature will be quite apparent.

In many instances the variation of the rate of cooling with a constant and somewhat higher silicon content is resorted to as a method of obtaining ideal engine cylinders. This method is peculiarly applicable to complex castings, which would otherwise be difficult, with a low silicon content, to obtain sound. The variation in the rate of cooling is most generally effected by the use of chills on the cylinder barrel core, and a great number of locomotive cylinders in particular are cast in this way.

With the use of chills the same point can be arrived at with a higher silicon content as with the lower silicon content and normal cooling. In this connection it is interesting to note a peculiar phenomenon. The analyses in the following table (Table VI) are taken from various portions of a steam-engine cylinder, as indicated in the table. The cylinder was chilled by means of ¾-in. chills attached to the barrel core. From the analyses it will be noticed that there is less combined carbon in the actual chilled face than in the portions which were not chilled. This is the result of the prolongation of the cooling period after solidification of the metal in contact with the chills, brought about by the highly-heated chills. This can largely be overcome by increasing the thickness of the chills.

TABLE VI.

Sample No.	Analyses.							Remarks.
	CC. per cent.	Gr. per cent.	Total C per cent.	Si per cent.	Mn per cent.	S per cent.	P per cent.	
1	0.303	3.00	3.30	1.70	0.82	0.08	0.66	Flange.
2	0.18	2.98	3.16	1.72	0.79	0.077	0.66	Portion not chilled
3	trace	3.33	3.33	1.68	0.92	0.079	0.64	Chilled portion.

These peculiar surfaces are close-grained and of high tensile strength, consequent upon the rapid cooling during the pre-solidification period. They are, however, somewhat soft, and contain very finely divided free carbon, possibly temper or annealing carbon, as a result of the dissociation of the pearlite carbide.

The question of the chemical constitution and its relation to growth and allied phenomena have been dealt with in a previous section. It will there be seen that one of the chief preventative measures to be taken against those phenomena is the elimination, as far as possible, of phosphorus.

From the point of view of wear and running properties this is not very satisfactory, and although very satisfactory running properties are obtained from cast-irons in which phosphorus is absent, it is the author's opinion that the presence of phosphide eutectic improves these properties considerably.

The use of chromium irons successfully overcomes this difficulty and they are, in fact, much superior to any phosphorus iron. By reason of its profound influence on increasing the stability of the carbide, it is possible, by proportionately adjusting the silicon and chromium contents, to produce a grey iron in which the micro-constituent cementite (in this case the double carbide of chromium and iron), is disseminated throughout the whole structure. In addition, the other advantages of the presence of chromium have already been pointed out.

In conclusion, the author would emphasise the immense importance of the continued study of the application of cast-iron to the design of engine cylinders and allied machinery parts.

The advent of the internal combustion engine and the consequent demand on all branches of the metallurgical industry for materials having the maximum physical and mechanical properties, is undoubtedly responsible for the great advance in the art and metallurgy of cast-iron. At the same time, however, it should always be borne in mind that the field of complex high-carbon alloys is still far from exhausted, and the author is convinced that, with the constant application of research in these realms, in conjunction with advance and improvements in the methods of manufacture, the labourer will reap his reward.

The author begs to tender his most sincere thanks to Messrs. Richard Hornsby and Sons for their permission to use the greater part of the information contained in this paper; and also to Messrs. Mirrlees, Bickerton and Day; to Mr. R. Onions, and the many other kind friends who have so readily placed information at his disposal: and also to the editor of ENGINEERING for the permission to reuse Figs. 1, 2, 5, 6, 7, 16 and 17.

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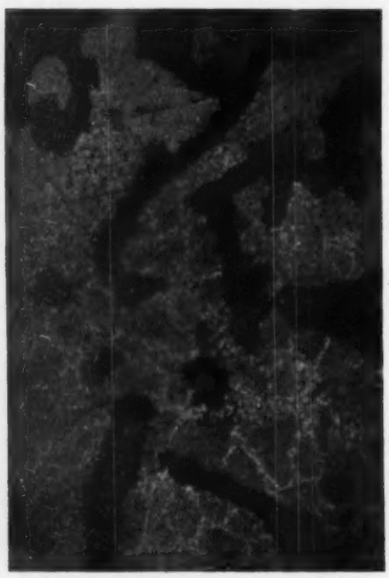


FIG. 19. ETCHED WITH PICRIC ACID; MAGNIFIED 250 DIAMETERS.

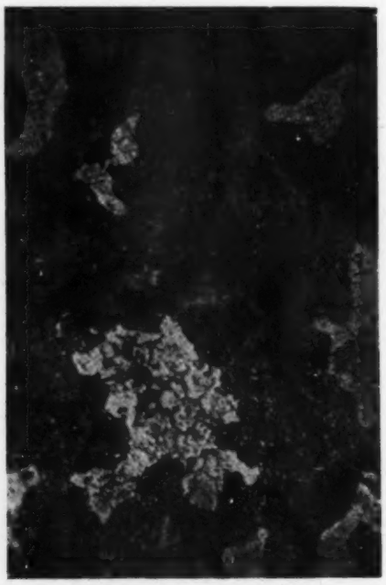


FIG. 20. ETCHED WITH PICRIC ACID; MAGNIFIED 250 DIAMETERS.

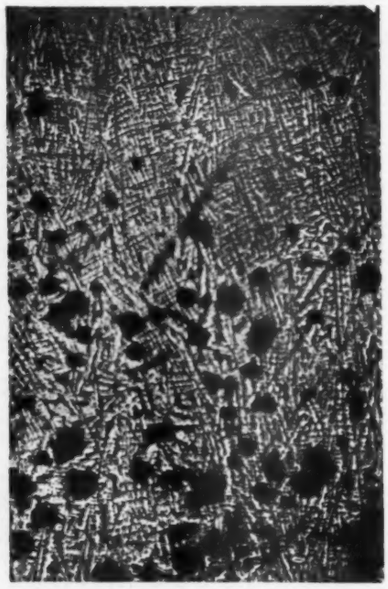


FIG. 21. SECTION FROM CHILLED SPECIMEN; ETCHED WITH PICRIC ACID; MAGNIFIED 75 DIAMETERS.

PROPOSED NEW COMMERCIAL HARBOUR AT KIEL.—The construction of a new commercial harbour at Kiel, specially intended for the large steamers trading on the Baltic, is under contemplation by the Kiel authorities. The new harbour is intended to be located opposite the Howaldt yard. The depth of water is 6 m. (about 20 ft.). The wharfage is about 420 m. (1,378 ft.) in length.

CONTINUOUS MECHANICAL DRYING MACHINE.

CONSTRUCTED BY MESSRS. D. & J. TULLIS, LIMITED, ENGINEERS, CLYDEBANK, GLASGOW.

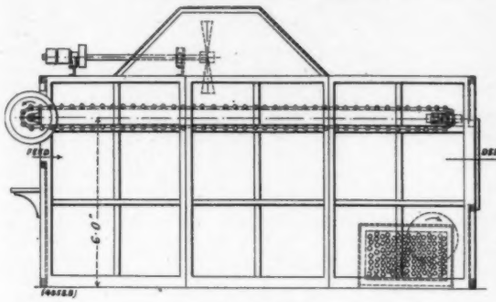


FIG. 1.

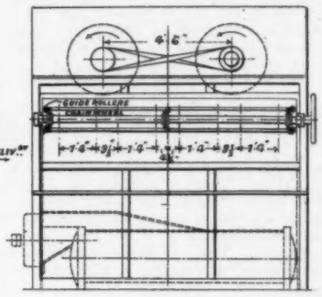


FIG. 2.

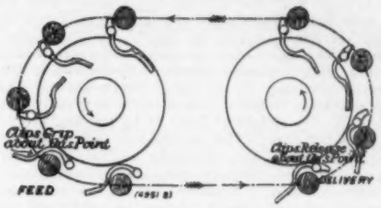


FIG. 3.

FIG. 4.

THE machine illustrated in Figs. 1 to 4 above has been designed for quick mechanical drying of any articles which it is possible to hang on the clips, and will doubtless interest managers of industries in which the process of drying forms a considerable part.

The system employed for drying is that of heated air in rapid motion circulated inside the chamber by propeller fans, either motor or belt-driven, of the ordinary ventilating type, in conjunction with a similar fan to supply and drive the air through a heater heated by live or exhaust steam, or it may be a coke fire. The former method of heating is, however, in general use, so we confine our remarks to it.

The apparatus carrying the material to be dried consists of endless chains supporting wood spars (Figs. 1 and 2), with metal clips or catches attached to grip the damp linen. The chains are stretched on two shafts with sprocket wheels, forming practically a roller, one at each end of the machine, and revolving in fixed bearings at the feeding end and in slide bearings at the delivery end. The latter are provided with screws to tighten the chains. The chains have rollers attached, running on rails along each side of the chamber. The material (or bags containing it) is fixed on the clips through an opening at the feed end, and the chain roller has a hand wheel attached to turn it. The feed roller is turned slightly to move the suspended material further into the chamber, and the next set of clips is loaded, and so on until the first set has reached the delivery end. When this is dry the roller is turned still further until the loaded clips begin to turn round the delivery roller, then they automatically release the material on to a platform or grating covering the air heater. The feed roller is generally operated by hand with machines of moderate size, but in a larger size power can be applied.

The two circulating fans are enclosed in a hood or canopy above the hanging spars, and drive the hot air down on the suspended material at one end of the room, and take it up again at the other, forming a complete circulation.

The air supply and heater fan are situated on the side at the delivery end of the machine outside, the heater being also at this end on the floor inside. The cool air is driven through the heater into the chamber, and is taken up by the circulating fans above. An exhaust-air outlet is formed on the top at the delivery end, and an average temperature of about 120 deg. F. is maintained inside. The air heater may be constructed either of steel tubes or with cast-iron gilled radiating pipes, and can be economically heated by engine exhaust. The chamber has an opening extending the full width at the feed end, with a hinged flap to lower when loading. The feed roller projects beyond this to the outside, and the flap can be raised close under the roller when the operator is not feeding it, this preventing loss of hot air. The delivery end has a sliding glass door, in halves, to be opened at intervals for taking out the linen. The chamber is generally bolted together in sections for extension; this can conveniently be carried out without incurring much alteration or expense.

The machine is generally used in 15 to 20 ft. lengths and 9 ft. wide inside, and of these dimensions is capable of a large output, the time allowed for average drying being about 25 minutes.

A general arrangement of the apparatus is shown in Figs. 1 and 2, while Fig. 3 indicates the action of the grips on the hanging spars. The apparatus is constructed by Messrs. D. & J. Tullis, Limited, of Clydebank, Glasgow.

The chief advantages claimed for this system, compared with other forms of drying, are these:—

The saving of floor space, the rapidity with which material can be dried, the reduction of labour in handling, and the fact that the operators are working outside in comparatively cool air.

It has also the advantage of portability, although it is sometimes incorporated with the works building for cheapness, either by adapting an existing drying-room, or by building it against an existing wall, with the framework carried up to the roof joists. The latter method facilitates light construction, particularly when the circulating fans, described above, can be supported on the joists, so that the drying chamber becomes then a cover to retain the heat and enclose the hanging spars, chains, &c. The latter are supported on the framework, and as a result the covering-in material and construction can be of a light description. In the present article we have dealt only with the machine as a portable unit, as shown in Fig. 4.

ITALIAN ELECTRIC RAILWAYS.

ELECTRIC traction on the Italian railways has largely developed of late years, and numerous lines formerly operated by steam in Liguria, Piedmont and Lombardy have been electrified with a view to enable them to deal adequately with increased traffic. In the work of electrification, standardisation is practised to as large an extent as possible, this being more especially the case with regard to the contact lines and the locomotives. At the present time, on a total of 700 km. (435 miles) of electrified lines, haulage is effected by practically one single type of engine, of which there are about 150 now in service for a total of 300,000 h.p. In the same way, the contact lines have gradually been rendered practically uniform both as regards suspension and insulation. In the present article we review the reasons which have influenced the Italian electrical engineers in their selection of a type of contact line suspension with the required insulating devices.

Overhead Suspension.—Of the two systems of suspension which from the commencement of railway electrification in Europe and in America were alternately to the fore, the longitudinal and the cross suspension systems, the latter only has found application on the Italian railways. Owing to the possibility it confers of maintaining at a constant level all the points of the contact line and of automatically regulating the tension of the line whilst securing a perfectly good insulation even with high voltages, the longitudinal system characterised by long catenary suspensions soon gained prominence in all countries over the cross system, whose application, so to speak, has generally been limited to tramway lines and to lines in mountainous regions. The Italian railway engineers, at the time of the first electrification work on the Valtellina railway, were faced with an entirely new problem, since that railway was the first to adopt high-tension three-phase current, there being two contact lines under different voltages. In these conditions the methods followed in other electrification work were hardly applicable, and it was necessary to devise a method which would meet the requirements of the system selected for electrifying the railway. Further, the latter runs through numerous tunnels, especially in the Lecco-Colico section, and all these circumstances together led, after a series of trials, to the adoption of a cross suspension, consisting of two wood posts, one on each side of the track, connected together by a wood cross-piece. The contact insulators are carried by an insulated wire stretched between the two posts.

The excellent results obtained with the new system of electric traction suggested immediately the possibility of applying three-phase current to other lines, together with all the other features which had given satisfaction. Moreover, the nationalisation of the railways helped to unify the schemes and led later to the electrification of other important lines.

The method of cross suspension was adopted for all the new lines, but not without having experimented

in the meantime, and after completion of the Valtellina railway plant with a longitudinal catenary suspension. The double track section Lecco–Calolzio, 8 km. (5 miles) in length, on a level and having no tunnel, was selected for experimenting with longitudinal suspensions manufactured by Messrs. Ganz and Westinghouse (Fig. 1, page 80). The experimental contact wires so laid were found quite satisfactory, both in regard to mechanical qualities and insulation. In 1914, after several years of inactivity, the experimental installation was put under current afresh, following upon the electrical working of the line Monza–Lecco. The plant was found suitable, even with the new polyphase engines, having speeds of from 75 to 100 km. (46 to 62 miles) per hour. The section was put in service without changing the insulators and without any repairs, a notable circumstance, seeing that during the years in which it remained unused the electrical equipment was constantly under the action of the smoke issuing from the steam locomotives. An objection to the longitudinal suspension is its cost, 50,000 lire per km. (3,200*l.* per mile), coupled with the very great complications at aerial crossings.

The reasons which have led the Italian railway engineers to prefer the cross suspension are, in the first place, the mountainous nature of the railways to be electrified, which makes it necessary to adopt an overhead construction which is both strong and simple. Further, the occurrence of numerous tunnels and the advantages of using one single type of suspension would in themselves have been sufficient to lead to the adoption of the cross type, for in tunnels with the longitudinal type the sag of the contact wire is too pronounced. The cross suspension, whilst simple, has the necessary strength to resist atmospheric disturbances on lines which are exposed to sudden gusts of wind. The aerial crossings are of much easier construction, and, finally, the cost of the cross suspension is about 50 per cent. less than that of the longitudinal. The cost estimated was 25,000 lire per km. (1,600*l.* per mile) of track, based upon a distance between the suspension points of from 20 to 33 metres (65 to 108 ft.), according as the track lay in curves of small radius (400 m. = 1,312 ft.) or in a straight line. In such conditions and with the highest speeds of the engines built for the new lines, 50 km. (31 miles) per hour, a sufficiently uniform contact of the collector against the aerial wire could be reckoned upon, together with the exclusion of the disadvantages in regard to current supply due to irregularities in contact on passing the insulators. A minimum cost of upkeep was also reckoned upon at the rate of 500 lire per kilometre (32*l.* per mile) per annum.

The results obtained in the course of over 10 years' operation are as follow :—

I. *Suspension in the Open.*—The wood poles adopted in the Valtellina plant were abandoned and preference was given to Mannesmann tubular posts, built up of two or more cylindrical sections of decreasing diameter towards the top, in such a way as to obtain practically a post having at every point the same resistance to flexure. Here it may be remarked that the post carrying an aerial wire being normally under a stress exerted always in the same direction, the circular section of the tubular type is not the one having the best efficiency, since it corresponds to a uniform resistance to flexure exerted in any direction It is well known that an ordinary lattice post of suitable design can withstand the same stress as a tubular one for a less weight of material, and that the cost of a tubular post per unit of weight is about 20 per cent. higher than that of the lattice post. But exclusive preference was given to the tubular post owing to its greater simplicity and its smaller dimensions, qualities which both facilitated erection and tended to increase the visibility of the signals. In this latter respect, it is easy to understand that the presence of numerous poles and the complex nature of the aerial system for a three-phase electric railway make it difficult to distinguish clearly the semaphores at a distance of a few hundred yards only. For this reason the tubular post was deemed preferable to the lattice post; notwithstanding this, however, in some of the large stations it was found advisable to erect the semaphores on a higher level than the normal.

There are about 10 types of tubular posts, varying in size and strength, according to their location and duty. On the main lines, both with single and double track, smaller poles are used, having a suspension bracket for one track. At the small intermediate stations the posts are for two tracks, with lateral brackets and poles for the aerial frogs. At the large stations single and double poles are used, with long brackets for carrying the aerial frogs over several lines. The brackets are frequently 16 and 18 metres (52 to 59 ft.) in length. Experience has shown that there is little advantage in resorting to such heavy suspensions with tubular posts, these showing their deficiency of strength by bending or by displaying an excessive elasticity, leading to notable oscillations under a strong wind or at the passage of locomotives, the trolleys of which always exert a somewhat high pressure against the contact wire. In the first lines electrified (the older Giovi line, the Mont Cenis and Savona–Ceva lines) the maximum distance between the poles was from 30 to 33 m. (98 to 108 ft.) in straight tracks in the open and from 20 to 25 m. (65 to 82 ft.) in tunnel. On the curves the distance was regulated in such a way that the chord of the arc subtended between two consecutive suspensions should not exceed 20 cm. (7.8 in.), this corresponding to a distance of about 20 m. (65 ft.) in the case of curves 400 m. (1,312 ft.) in radius.

On the basis of these figures the first cost of the installation was estimated to be 25,000 lire per kilometre (1,600*l.* per mile) of track. Difficulties rapidly arose which rendered it advisable notably to decrease the maximum distance between the suspensions. It is well known that in the cross suspension the wire hangs in a series of successive catenaries, having the vertex corresponding with the insulators to which it is suspended. Now, the current collecting bow, which is maintained in contiguity with the contact wire by means of an elastic system which gives it a pressure of 5 kg. (11 lb.), tends to produce a constant contact until the rapidity with which the sag of the contact wire varies during travelling exceeds certain limits, which can be determined on the basis of the pressure exerted and of the period of oscillation of the wire suspension bow. This, measured with the trolley lowered, is about 50 in., and the semi-period measured in the direction of travelling will be higher owing to air resistance. Taking into account the initial pressure it is found that this in every case is insufficient to follow with a constant contact the aerial wire of a line having the features of the first Italian overhead constructions. With a speed of 50 km. (31 miles) per

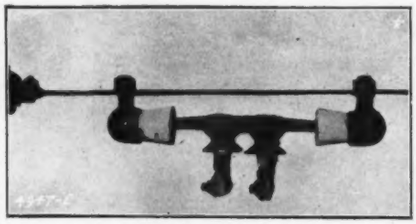


FIG. 6.

hour, there is a frequent arcing on passing the insulators, always followed by visible oscillations of the suspension bow in the direction of travelling and by a characteristic sign pointing to an increase in pressure. It is obvious that working with one collector alone is practically impossible in such conditions, and that an excessive sagging of the line due to accidental causes or to a large increase in temperature may lead to a violent shock against the wire of the successive spans, with the possibility of wear or of fracture of the collector. Such are, briefly, the disadvantages which surround a cross suspension. The assumption that the distance of from 30 to 33 m. between the poles, a tension of 300 kg. (660 lb.) at the contact wire, this being 50 sq. mm. (0.0775 sq. in.) in section, and a pressure of 5 kg. (11 lb.) on the bow against the trolley wire, would insure in every instance regular current collection, was erroneously maintained at first on the Italian railways. The influence of the summer temperature, any irregularity in the adjustment of the trolley and the possibility of ultimately having to exceed the maximum speed adopted of 50 km. (31 miles) per hour, led to a notable decrease in the maximum distance between the suspensions and to an increase in the pressure of the trolley and in the tension of the contact wire. In the lines recently built and in those in course of electrification it has been decided to maintain a constant spacing of 20 m. (65 ft.), whether in the straight or in curves, and in the open or in tunnel. These conditions combined have raised the first cost to 35,000 lire per km. (2,250*l.* per mile).

The bow carrying the contact insulators is fitted to a tubular bracket suitably stiffened by one or more tie rods according to its length. The top part of the bow is circular (Fig. 2), and can easily adapt itself to irregularities in the positions of the fixing stirrups, this feature being utilised in the curves, where the wires of the outside phase are raised above those of the other phase in the same way as the outside wheels of the rolling stock are raised above the inside ones, with a view to maintain a more regular contact pressure of the current collectors. The contact insulators are carried by a suspension wire stretched between two insulators located at the ends of the upper supporting bow (Fig. 2).

In the stations the bracket is tubular, with suspensions for multiple tracks. Over some tracks, where the aerial frogs are numerous, the brackets of posts opposite each other are connected together, thus forming a kind of bridge suspension which acts satisfactorily in that it tends to reduce oscillations due to the very heavy weight of the aerial structure. In the large stations double tubular poles are used to carry long double brackets having tie bars made of lattice-work with the object of eliminating horizontal oscillations, which are, however, prevented by the contact wires, whilst it would have been more important to eliminate the vertical ones, which manifest themselves to a marked degree under a somewhat strong wind. In other stations a cross catenary has been adopted, in which the conductors for all the tracks are carried by a catenary suspension stretched over the outside tracks. This system has the advantage of rendering the whole of the station site free from posts; it has, however, been found difficult suitably to regulate the tension of the suspension wires, with the result that there occurs a tendency to marked oscillations. On the other hand, a suspension of this type has been found most suitable under the roofs of large covered stations.

II. *Overhead Work in Tunnels.*—The materials used for the suspension in tunnels have to be selected with reference to their resistance to oxidation, and this point is of importance, more especially in the case of lines on which both steam and electric traction are resorted to. The acidity of the smoke and water vapours produces notable chemical effects, leading to the corrosion of the metallic portions of the suspension devices. In the old Giovi line tunnels all the iron threaded fittings were found to deteriorate rapidly, especially at the points of contact of different metals, where most active chemical reactions took place, so much so that in the successive renewals copper alone, or copper alloys containing no zinc, had to be resorted to, a fact which largely increased the cost of the work.

The suspension device adopted for the tunnels of the old Giovi line (Fig. 3, page 80), consists of two iron bars inserted vertically in the arch, 1.20 m. (3 ft. 11 in.) apart, with two strong eye-gripping devices of brass at the lower ends, as shown in the illustrations. Usually the bars are 35 mm. (1.378 in.) in diameter and 700 mm. (27.6 in.) in length, and are inserted in the arch to a depth of about 350 mm. (13.8 in.); the eye-grips are fixed in the side walls to a depth of 250 mm. (9.8 in.) at a height of 4.85 m. (about 16 ft.) from the rail level. Between each eye-grip and the end of the nearest bolt is stretched an insulated wire which supports the contact wire insulators.

In the more recent lines this very simple, but insufficiently strong, suspension was abandoned, and the tunnels were fitted with more rational and safer devices, in which regard was also had to the oxidising action of the smoke and the chemical effects of the earth currents. Two main bolts fitted into the arch carry the whole aerial system (Figs. 4 and 5). In the single-track tunnels the bolts carry a bar fitted at the ends with insulators, from which are suspended the contact line insulators. In the double-track tunnels a double T horizontal frame (Fig. 5) is fitted to the main bolts, the frame carrying laterally the two brackets which support the aerial wire. This latter method of suspension has given good results in the Mont Cenis tunnel, 14 km. (8.7 miles) in length, and in the Ronco tunnel, the length of which is 8 km. (5 miles).

Insulation.—Whilst the insulation of all current transmission lines is a most important feature, the difficulties met under this head are great and cannot be said to be satisfactorily solved. The insulation of a contact wire in a tunnel is specially difficult to obtain, and the problem is more complicated still when, as occurs on some of the Italian lines, the service is both electrical and with steam. Even when putting down a new installation for electric traction, the electric railway plant is for several months, during erection, under the action of the smoke from the steam locomotives, which covers the insulators and the wires with a thin layer of carbon dust which, under the further action of the steam from the engine, rapidly affects the insulation of the insulators. It may be noted here that it appears easier to obtain good insulation from an insulator maintained from the first under tension and not immediately exposed to the action of the smoke. On the Italian lines the practice is now followed of putting the lines repeatedly under electric tension as soon as they are mounted, and then immediately protecting all the insulators by cloth or straw coverings until the time when current is sent through the line for actual service.

The insulator of a railway line wire has constantly to meet many varying conditions from both the electrical and the mechanical points of view. The current pressure varies from 3,000 to 3,500 volts, with normal excess voltage up to 4,000 volts. The mechanical stresses are most varied, since the tension of the line varies within wide limits with the temperature; other irregular stresses have also

to be taken into account, occurring, for example, during erection and inspection. The intermittent passage of the electric locomotives, the trolley of which exerts a somewhat high pressure on the contact wire, the action of the curved sections, of damp and frost, are all elements which have further to be taken into account in the design of insulators, which latter have, moreover, to be easy to fit and to replace, and of reasonable cost.

The problem on the Italian lines is one which has been taken up with great interest by railway engineers, and when electrification was proceeded with on a large scale its importance was immediately recognised. The first types adopted, which had been supplied by private firms, were abandoned and the State Railways undertook to supply them direct with a view to economy both in first cost and in the cost of renewals. The Italian lines electrified during late years form, therefore, in this respect, an interesting experimental field on a large scale, in which new types of contact insulators have been experimented upon under stringent traffic conditions on lines of great importance, having numerous sections in tunnel. The problem appears now to be finally solved, although perhaps not so economically as was at first anticipated. Since April, 1916, the electric lines have worked regularly, notwithstanding the excess traffic due to the war, and in regard to efficient insulation the Italian railway engineers are able to undertake with certainty of success the important work of electrification now in contemplation.

The first insulator adopted on the Valtellina lines comprised a stem insulated with ambroin, a compound of mica and asbestos with fossil gums and resin, and having at its lower end the clamp for holding the contact wire. It is surrounded by a cast-iron protection bell made with ribs for fixing to an insulated wire stretched between two poles. The insulators are of different patterns according as they carry the contact wire over sections in the straight or in curves, in the open or in tunnels. The difference, however, is in small matters of detail only. This ambroin insulator, although of single insulation, and of reduced weight and cost (its price is only 12 lire = 9*s.* 6*d.*), gave excellent results, both in regard to mechanical resistance and insulating property, as is shown by the fact that a large number of the original insulators of the Valtellina railway are still in use.

The Brown-Boveri insulator (Fig. 6, page 78), adopted for the Simplon line, was used for the first time on the old Giovi railway. This is an horizontal porcelain, double-bell insulator; between the two bells is located the yoke, fitted with the two clamps, themselves insulated by two ebonite blocks. The yoke, of iron or of brass, is cemented to the porcelain by means of a special compound which confers to the insulating device sufficient elasticity to enable it to accommodate itself to great variations in temperature or abnormal mechanical stresses The present Brown Boveri insulators are of various patterns. Over curves and at stations they are provided with two separate clamps, since the two monophase wires of each aerial phase are at a distance of about 6 cm. (2.3 in.) from each other; in the straight the two monophase wires are joined and are held by double grooved clamps. At the frogs the insulators differ from those of main lines by a few details in the fittings. With these insulators there is quadruple insulation between the two aerial phases and treble insulation between the wires and the earth, taking into account the lateral insulators of the suspension bracket. The anchoring of the insulator is well designed, since it allows of a good distribution of the stresses under the action of the live wire in curves; further, the lower wire support of the suspension bracket aids the action, so as to reduce to a minimum the bending stress on the stem of the insulator. This type of insulator has shown excellent mechanical strength and a strong insulating power. In tunnels, however, the results have not been entirely satisfactory, whilst in the open a number of such insulators are still on the line, where they have withstood over six years of service. Their high cost led the Italian State Railways to design their own type for all their lines, known as the F.S. type.

The F.S. type of insulator is an imitation of the Brown-Boveri insulator. It consists of three porcelain bells, mounted triangular fashion, and connected together by a yoke of iron or brass. The lower bell has a double clamp, the pattern of which is the same for all insulators, whether used over straight tracks or over curves. This type of insulator, used for the first time over the Mount Cenis line, in 1912, was very soon after modified, both in the yoke and in the porcelain parts. The new, improved type was then used on the Savona-Ceva line. In the F.S. elements the insulation of the lower bell was found to be inefficient; in rainy weather and especially on the Mount Cenis line, partial or complete brush discharges were observed on numerous insulators, leading to current interruptions. The insufficient mechanical strength of the insulators was perhaps contributory to this occurrence. At the present time these insulators are only found on the Savona-Ceva and the Mount Cenis lines, especially at the stations.

The "Succursale" type of insulator followed the F.S.; their name is derived from that of the line, "Succursale dei Giovi," on which they were used for the first time. The "Succursale" type consists of two insulators, one over the other, and joined together by means of a cast-iron envelope (Figs. 7 and 8). The two elements have each a cavity in which is cemented an iron core having a threaded stem projecting outside. The upper screw serves for fixing the insulator to the suspension bracket, and the lower for carrying the yoke, with two clamps for holding the contact wires. The threaded stems have a longitudinal slit, which gives them the required elasticity to meet great variations in temperature. The adoption of the "Succursale" insulator was extended to other lines in construction and in working, even before a sufficiently lengthy experience had confirmed its good electrical and mechanical qualities; it did not, however, give the good results that were expected. The satisfactory initial insulation decreased rapidly, probably following upon deterioration due to variations in temperature and to irregular tension in the live wire, so that a very large proportion of insulators had to be replaced on all the lines after a few months of working. The mechanical strength of the insulator leaves much to be desired. Its shape is such that it does not allow a rational fixing to the suspension bracket, and it does not offer a satisfactory resistance to the bending stresses met with in curves; hence a notable permanent bend is quickly developed in many insulators at curves, more especially on the lines where the curves are frequent and of small radius, such as on the Savona-Ceva line.

A few modifications were recently made, which otherwise left intact the original shape of the insulator. The new "Succursale" insulators are now widely distributed over the greater part of the lines already built or in course of electrification. Since they have been adopted only recently, it is not possible so far to say what their ultimate electrical resistance will be. In order to increase the strength two insulators can be coupled together in parallel in all the curves; this, whilst proving a satisfactory solution, is not an economical one when it is considered that on all the Italian lines about 50 per cent. of the aerial supports are required to be over curves.

With the "Succursale" insulator a lateral insulator (Fig. 9) was adopted with a suspension bracket of entirely similar construction, but formed of one element only. By this means, again, there was obtained a quadruple insulation between the two aerial phases and a treble insulation between one aerial phase and earth.

(To be continued.)

"SEA POWER."—At the present time, when so many people are inclined to be impatient, owing to ignorance, as to what the British Navy is doing, Messrs. Constable and Co. are to be congratulated on publishing, at the popular price of 1*s.* net, an admirable summary of the history of the great wars, in order to elucidate the principles and practice of sea power and command of the sea. The title of the book is "Sea Power," and the author is Mr. Archibald Hurd, a well-known writer on naval subjects. In his introduction Mr. Hurd states that in the present volume he has endeavoured to apply "Mahanism," showing the dominating influence which sea power has exercised on the two branches of the Anglo-Saxon family, separated by the Atlantic, and on the British nation in particular. He has certainly thrown light, as he himself hopes, on "the curious paradox that in a world whose history has apparently been moulded by soldiers, the nations which have always supported exiguous armies possess not only so much territory, among the most fruitful in the five continents, but have been able to cherish lofty ideals of personal and communal freedom without disturbance." In his broad interpretation of the meaning of sea power he shows that those nations which are opposed to offensive wars—that is, wars of attack—act on the principle that sea power controls land power, and so long as they possess the former they may have little to fear from the latter. Having, in his first chapter, "Command of the Sea," explained exactly what this means, with examples from recent history, he proceeds to review the effect of sea power in all the world's great wars, quoting with great discrimination from many classic writers, and he concludes by a brief consideration of the effect of the British Navy on the course of the present great war. He establishes the fact that had it not been for the British Navy, the German fleet, as against France and Russia, would have secured the command of the sea, the power to take the allied armies in the flank or rear, and to prevent them using the seas for any purpose. The book is written in simple language, which can be "understanded of the people," and in view of its cheapness ought to be closely studied by all. It would be an admirable thing if those responsible for the education of our young would use it as a basis for simple lectures to their scholars, so that they might acquire a clear idea of the fundamental principles of Britain's "first line of defence."

HYDRAULICALLY OPERATED WATER-TIGHT DOORS.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of the 15th ult. Messrs. Nisbet and Co., Limited, made an apology for a statement in the book, "Eclipse or Empire?" recently published by them, describing the hydraulic watertight door system as of German origin.

In the apology Messrs. Nisbet state "they have now ascertained that Messrs. J. Stone and Co., Limited, of Deptford, control, and have always controlled, the power system for closing watertight doors which they have so extensively supplied to first-class passenger vessels."

We have been in communication with Messrs. Nisbet on the subject, but they claim that the words mean nothing more than that Messrs. Stone control the system which they use. That this, however, is not the interpretation which most readers will place upon the words is evidenced by letters from friends drawing our attention to the matter.

For 22 years we have been engaged on this work, and are the original inventors of the hydraulic system of control, and at the present moment are engaged in supplying to no less than seven vessels our patent system, over which Messrs. Stone have no control.

As the words are liable to misinterpretation and are calculated to do us harm, we ask you to be good enough to insert this letter in your next issue and oblige

Yours faithfully,

BRUNTON BROTHERS, LIMITED,
(John L. Brunton).

17, St. Stephen's House, Victoria Embankment, Westminster, London, S.W., January 19, 1917.

[We publish Messrs. Brunton Brothers' letter; but at the same time we must say that Messrs. Nisbet's interpretation of their statement is perfectly correct, and we do not understand how it could possibly be regarded as applying to arrangements for operating watertight doors not manufactured by Messrs. J. Stone and Co., Limited.—ED. *E.*]

ELECTRON, QUANTA AND RELATIVITY THEORIES.

TO THE EDITOR OF ENGINEERING.

SIR,—*Tu quoque* will not help us very much; but I shall feel grateful to Mr. Edwards if he will kindly correct that sentence of mine which he quotes without context as an example of the "careless use of expressions." My point was that "heat," being a mode of motion, could not *enter* into any substance, and so raise its temperature.

May I once more deny the propounding of a conundrum? I simply put Mr. Edward's words into the form of a question, to which his latest reply is: "A ray of light is also a ray of heat or of energy, or of momentum, and it can enter a transparent substance at any point." To make things quite clear, perhaps Mr. Edwards will be so good as to tell us what the temperature may be of a "ray of heat" on its way through interstellar space between the sun and the earth's atmosphere.

Maxwell's use of "Matter and Motion" or "Matter and Energy" as sub-titles does not justify their being used in a different way altogether! About ten years before the appearance of the "small work dated 1888" Maxwell had written (the italics are mine):—"When we have acquired the notion of *matter in motion*, and know what is meant by the energy of that motion, we are unable to conceive that any addition to our knowledge could explain the energy of motion, or give us a more perfect knowledge of it than we have already"; from which it is evident that Maxwell avoided the mistake made by Mr. Edwards.

The concluding paragraph of his letter of the 13th is excellent. It is in itself worth all the space which you, Sir, have so generously given up to our little discussion; and I trust it will encourage many of your readers to think on their own account—and to try to think clearly.

January 20, 1917. SESAMY.

A NATIONAL BRITISH TRADE MARK.—At a meeting of the Sales Managers' Association, held in London on the 18th inst., Mr. Edwin T. Nind put forward a proposition to the effect that every article of British manufacture should bear a distinctive official national trade mark, to imitate which would be both forgery and treason, punishable by severe penalties. He did not think the man in the street had any real conception of the extent to which the people of this country had been purchasing goods of enemy manufacture.

THE AERONAUTICAL SOCIETY OF GREAT BRITAIN.—The Aeronautical Society of Great Britain opened its 52nd session with a lecture by General Brancker, R.F.A., on Wednesday, January 24th, at the Institution of Civil Engineers. Had it not been for the war, the society would have celebrated its jubilee last year. The society, which was founded in 1866 by the Duke of Argyll, Sir William Fairbairn, and others prominent in their day, has throughout devoted its attention to the development of the science in a quiet and business-like way. The war has brought aeronautical science into the forefront as a definite branch of engineering, and the more prominent firms of aeronautical engineers are identified with the society which develops the science. The Society of British Aircraft Constructors and the Aeronautical Society are in close communion in the matter. It is desired that all of those interested in aeronautics should become members of the society. Its definition of qualification is wide, as it has room for students, experts and all who are interested as amateurs in the advancement of the science.

ITALIAN ELECTRIC RAILWAYS.

(*For Description, see Page* 77.)

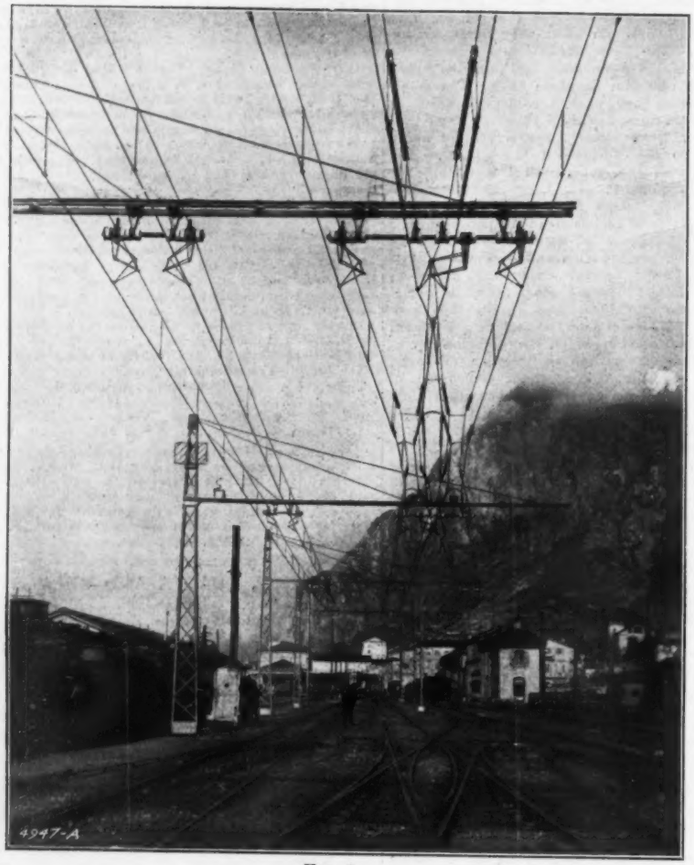


FIG. 1.

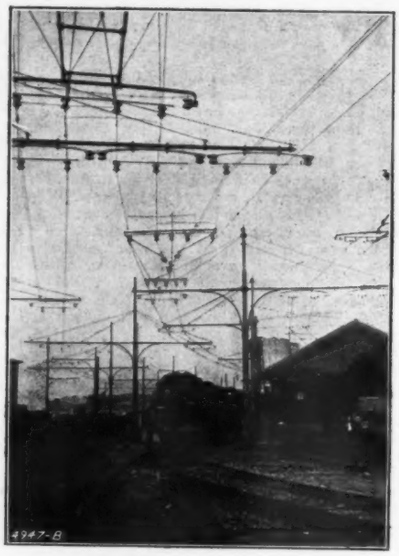
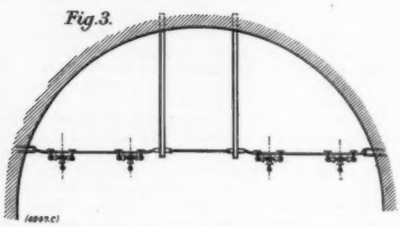
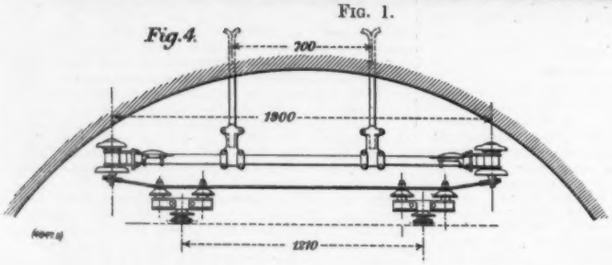
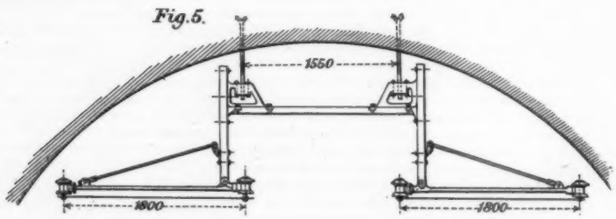


FIG. 2.







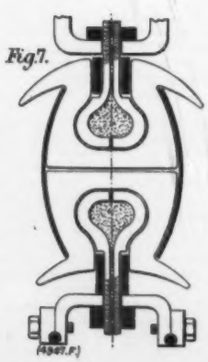


FIG. 8.

FIG. 9.

AGENTS FOR "ENGINEERING."

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8506 GERRARD.

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With a Two-Page Plate of the WOOLWORTH BUILDING, NEW YORK; DETAILS OF WIND BRACING.

NOTICES OF MEETINGS.

THE ROYAL SOCIETY OF ARTS.—Monday, January 29, at 4.30 p.m. Cantor lecture.—"The History and Practice of Town Planning and Civic Architecture," by Professor A. Beresford Pite, F.R.I.B.A., Royal College of Art, South Kensington (Lecture I). Tuesday, January 30, at 4.30 p.m. Colonial Section.—"Imperial Industries after the War," by Mr. Octavius C. Beale, Representative and Past-President of the Australian Associated Chamber of Manufacture. The Right Hon. Walter H. Long, LL.D., F.R.S., M.P., Secretary of State for the Colonies, will preside. Wednesday, January 31, at 4.30 p.m. "The Work of the Y.M.C.A. in France," by Miss Ella C. Sykes. Colonel Sir Thomas H. Holdich, R.E., K.C.M.G., K.C.I.E., C.B., D.Sc., will preside.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, February 2, at 5.30 p.m. The evening discourse will be delivered by Mr. Charles Carpenter, D.Sc., M.Inst.C.E. The subject is "The Supply of Gaseous Energy" (experimental). Afternoon lectures next week at 3 p.m. Tuesday, January 30. Professor Charles S. Sherrington, M.D., LL.D., D.Sc., F.R.S., Fullerian Professor of Physiology, R.I., on "The Old Brain and the New Brain, and their Meaning" (Lecture III). Thursday, February 1. Professor F. G. Donnan. M.A., Ph.D., F.R.S., Professor of General Chemistry, London, on "The Mechanism of Chemical Change" (Lecture I). Saturday, February 3. Mr. Henry Walford Davies, Mus.Doc., LL.D., on "Line in Plain Chant and Folk Song" (Lecture I).

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, JANUARY 26, 1917.

MACHINERY AND THE COST OF LIVING.

THE taking of a true perspective is one of the difficulties of the untrained thinker. There is too great temptation to accept facts within one's own personal knowledge, too little tendency to dip deeply into history or to sift distant facts, in orde that the influences of present-day events may be illuminated by the experiences of the recent or remote past. The consequence is that a full measure of the importance of passing events cannot be obtained. This applies with special force to the influence of machinery on the cost of living, and still more on the extent of employment available and on the true wage earnings of the worker. And yet this problem is one of the greatest significance in connection with the prosperity of the working classes, even more than with that of the capitalist or "well-to-do." The margin upon which the average working man's family has to operate in balancing income and expenditure is enormously less than in the case of the well-to-do, and anything which will increase this margin must be of great advantage. Consequently, if by the co-operation of capital and labour the productivity of labour can be improved for a given expenditure, the gain accruing to the working classes must be of marked benefit.

The increased production must be achieved principally by the introduction of mechanism, whereby, with the expenditure of a given amount of personal effort, either mental or physical, the volume of the output is increased. If this result be achieved the value due to increase in manufactures is available for higher earnings to the worker, for adequate return on the capital involved for the mechanism necessary for greater manufacturing efficiency, and for a reduction of the selling price. Unless all these three gains accrue there can be no true general advantage. The capitalist must be stimulated to further enterprise, the worker must be encouraged to greater effort, and the buyer must be induced to multiply his purchases, so that the demand for the services of the worker and capitalist may be maintained. In the past capitalists have been lax, partly through mental indolence or the failure to recognise the fundamental principle that manufacturing efficiency is the determining factor in commercial prosperity, and partly by the doubt as to whether the new appliances will yield the triple advantages already enumerated. The worker, through a lack of faith—which, unfortunately, is not without some measure of justification—looks with suspicion on any means whereby the output per worker can be augmented. He fears unemployment; he thinks that the whole of the result of the combined enterprise of employer and increased labour production should be handed over to labour. Only if the latter idea be applied can the former result be possible. The whole history of industry has established the fact that reduction in the cost of manufacture and its selling price tend to increase the demand and stimulate its use; without exception the ultimate result has been increased demand for labour, higher earnings, and greater comfort for the working classes. It is true that revolutionary changes resulting from inventions which have suddenly multiplied many times the production of any given manufacture have involved momentarily dislocation of employment. Therein is some justification for the fear of the worker; but this does not apply to evolutionary changes, and in any event, when one takes the long view, for which we contend, there is the possibility of clearer judgment, and therefore a readier acceptance of the truth that machinery must increase earnings and reduce the cost of living.

It follows that no opportunity should be lost by all thinkers of inculcating the principles of due perspective in the study of industrial history. Nor should there be any hesitancy in bringing forward the salient results from such a study, because unless this is done the changes of a day cannot be understood, since their effect is not illuminated by the general trend of events throughout the years and centuries. In the James Watt anniversary lecture delivered on Friday evening last, at Greenock, by Dr. G. B. Hunter, he did well to treat with wide perspective the influences of machinery, which directly resulted from the primary invention of the great Scottish engineer, upon all the industries which affect the prosperity of the working classes. Without steamships, railways, mechanical agricultural appliances and milling machinery, food-stuffs, particularly grain, could not be delivered into the working-man's home to-day at a fraction of the rate required a century ago, when everything was done at great physical effort by purely manual work. One hundred years ago wheat was sold at 126*s.* 6*d.* per quarter, as against 32*s.* 1*d.* in 1913. Here is one of the most convincing proofs of the advantage of machinery. This result has been achieved entirely because the productivity of labour has been augmented in an enormously greater ratio than the labour cost involved. Dr. Hunter is responsible for the statement that because this principle has also been applied to shipbuilding ships are to-day 50 per cent. cheaper than thirty years ago, whereas in the building and allied trades, where wages have increased at an even greater ratio than the volume of output, all buildings cost 50 per cent. more than thirty years ago. Thus, we have, as a result of cheaper ships, and consequently greatly reduced rates of freight for transport oversea, a reduction in the cost of food and raw material for manufactures, with immense gain in respect of the cost of living, as well as in the extent of employment. On the other hand the working classes are called upon to pay rents 50 per cent. more than they should were manufacturing efficiency and economy achieved in the house-building trade to the same extent as in the construction of ships. Several other contrasts could easily be made. We might instance the great decrease in the working cost of railway lines due to higher mechanical efficiency, and a consequent reduction in overland freight rates, notwithstanding increased wages; on the other hand, there is the tendency in coal mining to make wages directly proportional to the selling price of coal. In the latter case the users of coal—and every working man must have his supply of household fuel—have to pay more because of the temptation to lessen output, to regulate market prices, to increase the selling price and consequently advance the wages of the worker. The principle is wrong, although apparently accepted because it is a simple one for adjusting wage rates. It removes that incentive towards mechanical efficiency which, as we have contended, is the first principle of commercial prosperity.

That this extension of mechanical power has been not only beneficial in reducing the cost of living, but in augmenting earnings, Dr. Hunter had no difficulty in establishing. He showed that the artisan's real wages, taking into account the cost of living, were 100 per cent. greater than in the years immediately following the Napoleonic era, while

agricultural workers were 77 per cent. better off; Indeed, at no time in the history of England would the conditions of the workmen compare with those of the present. Taking 1850 as a starting-point, the years 1865–9 showed an increase of 10 per cent., 1875–9 an increase of 30 per cent., 1885–9 an increase of 50 per cent., and the years 1895–9 an increase of 90 per cent.; in fifty years the real wage was quite doubled. Again, on the other side of the balance sheet, there is the fact that in 1881 food and drink were 39 per cent. higher than at the beginning of this century. In European countries generally real wages per hour worked are 20 to 30 per cent. lower than in this country, notwithstanding that the working week is of from 58 to 60 hours, instead of 54 as in this country. Miners' wages on the Continent are about 40 to 50 per cent. less. In the United States and some of our colonies, however, money wages and real wages are higher than in this country. This, Dr. Hunter contended, was due to two causes, the natural wealth and resources, and the increased output of labour per worker, a result of improved mechanical appliances, more favourable raw material, greater exertion of the workers, or better organisation in the establishments, or of all of these combined. The statement of the problem is simple, its solution a great difficulty, which requires patience in negotiation, enlightenment, and a definite desire for the good of the whole of the people.

LLOYD'S RESPONSIBILITY FOR VESSELS BUILT TO LLOYD'S REQUIREMENTS.

MR. JUSTICE SANKEY, in the King's Bench Division, has given an important judgment, in which Lloyd's Register of British and Foreign Shipping, as defendants, successfully resisted an action by a firm of shipowners for the amount of damage caused to a ship, the plans of which were in accordance with Lloyd's rules, and the construction of which was supervised under Lloyd's Register. The history of the case may first be stated, the owners having in a previous case sought unsuccessfully to make the builders responsible for the damage. The vessel in question was a steel screw steamer named the Ajana, built by a Clyde firm, Messrs. Russell and Co., Port Glasgow, for the Australind Steamship Company, and intended for the Australian trade. According to the specification the vessel was to be built to Lloyd's requirements for 100 A 1 class. The survey classification fees were to be paid by the builders. There was to be no alteration to the specification unless agreed to by the owners.

A feature of the design of the vessel was the fitting of widely spaced pillars between decks, and Lloyd's Register approved of the midship section, showing the pillars and girders. The vessel was built in accordance with these plans, and a certificate for classification duly granted by Lloyd's. The vessel made her maiden voyage to Australia without mishap, but on the homeward trip (with a cargo of wool and ore stored in the ordinary way) the foundations of six of the hold pillars gave way, notwithstanding that the weather was ordinary. The tank top and decks, and other structures which the pillars were designed to support, collapsed, the damage to the hull, according to the steamship company, amounting to 10,745*l*. The contention was that the pillars were built on weak foundations, with no seating to them in order to distribute the load, so that the pressure was too much for the floors on which the pillars rested, and they consequently tore away, the whole of such parts of the ship becoming distorted, twisted, and buckled.

When, eighteen months ago, the steamship company sued the builders, the case was heard by Mr. Justice Bailhache, but prior to this the question of liability had been remitted to an arbitrator, and on inquiry he found that it was not possible to ascertain the strength of the foundation of the pillars, and that there was no breach of duty or contract by the builders in accepting and acting on the requirements of Lloyd's with regard to the foundations of the pillars, and in not making calculations themselves. He found that the plans were submitted and approved on the owners' behalf by the superintending engineer, but, in his opinion, this approval was not intended to relieve, and did not relieve, the shipbuilders from any warranty or obligation incumbent upon them under the contract. He decided that there had been no breach of contract by the shipbuilders, and that they were under no liability to the shipowners for the damage caused by the giving way of the foundations of the pillars. The shipbuilders in this case were awarded costs. On the steamship company appealing against the arbitrator's decision, a special case was stated by him for the opinion of the King's Bench Division. The steamship company contended that, under section 14 of the Sale of Goods Act, there was an implied warranty of fitness, but the shipbuilders, on the other hand, contended that the term "to the satisfaction of Lloyd's" embraced in the contract wiped out any implied obligation of fitness for the purpose for which the vessel was required. Mr. Justice Bailhache dismissed the appeal with costs, and in giving judgment said: "The respondents' (the shipbuilders') counsel had satisfied him that the points on which the appeal was taken were questions of fact, and that upon those questions the arbitrator had made specific findings and left him nothing to decide. From what he knew of the arbitrator, he was sure he did not intend to shut off the parties from taking another judgment on the points raised, but having regard to the form of the award and the findings, he thought the arbitrator had practically ruled the appellants out of court."

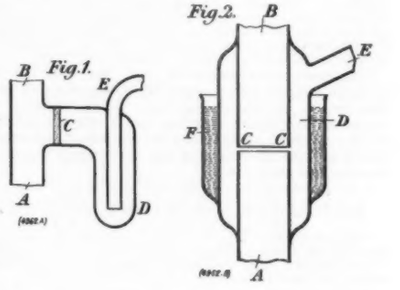
Following upon this decision, the steamship company raised an action against the chairman, deputy chairman, and trustees of Lloyd's Register, claiming the amount of the damage suffered by the ship on her homeward voyage from Australia. In this case the steamship company contended that it was the duty of Lloyd's Register to make all reasonable and necessary calculations to ascertain whether the foundations of the pillars were of sufficient strength and reasonably fit to support the weight which in the ordinary course would be put upon them; otherwise their plea was that there was a breach of duty or negligence on the part of Lloyd's Register. Lloyd's Register, in their defence, denied that they owed any duty to the plaintiffs, and relied upon section 26 of their rules, which excepted the committee from liability for inaccuracies in any report or certificate, and for any error of judgment, default, or negligence of the surveyors or other officers or agents of the society.

In his judgment Mr. Justice Sankey held that there was no evidence of any contract between the steamship company and Lloyd's. A number of facts had been pleaded in order to establish the inference that there was such a contract. The only contract was between the shipowners and shipbuilders for a vessel to be built in conformity with the rules of a third party, namely, Lloyd's Register. He was unable to see that that contract made a contract between the plaintiffs and the present defendants. The plaintiffs, in his opinion, had entirely failed to make out that there was such a contract. The next point was whether there was any duty on the part of Lloyd's Register which gave the shipowners the right to sue on a plea of negligence. Mr. Justice Sankey said: "It was idle to talk of negligence unless the party charged with it was under some duty. It had been said that a person might be as negligent as he liked unless he owed a duty to the person seeking to make him liable." Answering the question, What duty could it be suggested that Lloyd's Register owed to the shipbuilder in connection with the ship?—Mr. Justice Sankey again relied on the fact that there was no contract except between the shipowner and shipbuilder, Lloyd's Register inspecting and passing the vessel. The only duty which Lloyd's Register owed was to the builders. The only persons doing work on the shipowners' property were the builders. Lloyd's Register were only asked to approve of the plans of the vessel, and then to see whether the vessel had been built in accordance with those plans, and, following compliance with the plans, to issue their certificate. Mr. Justice Sankey was so satisfied that the shipowners had no contract with Lloyd's Register, and that the latter owed no duty to the former, that he gave his judgment on this point, and felt it unnecessary to consider section 26 of Lloyd's rules, already quoted. The plaintiffs had no contract with the defendants, and the defendants owed no duty to the plaintiffs. Judgment has therefore again gone against the steamship company.

THE CONDENSATION HIGH-VACUUM PUMP.

IN our issue of August 25 last we illustrated a new high-vacuum mercury-vapour pump, the development by Dr. Irvin Langmuir of the diffusion pump which Dr. W. Gaede, the originator of the molecular pump and of other remarkable types of pumps, had brought out in 1915. When describing his new pump in the *Physical Review* of July, 1916, Dr. Langmuir mentioned that he had, in the research laboratory of the General Electric Company at Schenectady, already succeeded in constructing simpler forms than the first experimental and rather complicated pump, with which he had realised a high vacuum at extreme speed. The December number of the Journal of the Franklin Institute contains a further instructive article by Dr. Langmuir on these researches and on his improved condensation pumps, which he makes of glass or of metal. The improvements involve the application of the condensation principle, the term being used in a novel sense, and before describing the pumps we will refer a little more fully than we did on the previous occasion to the principles of the diffusion pump, and also of the condensation pump. We are indebted to the Journal of the Franklin Institute for our illustrations.

The main idea in these novel devices is that a blast of mercury vapour carries the air or gas to be evacuated into the condenser, in which the mercury condenses; the condenser is connected with the



"rough" pump, which has to maintain a pressure lower than the vapour pressure of the mercury in the flask in which the mercury blast is produced by heating. Various methods may be employed for the purpose of making the air enter the mercury vapour blast. Gaede* applied the diffusion or aspiration principle in a way which Fig. 1 may help to elucidate. A jet of steam or mercury vapour passes up the tube AB, past the porous diaphragm C; the vessel to be exhausted is connected to the tube E, which ends in the bulb D; D is a vapour trap placed in a cooling mixture. Vapour will penetrate through C into D, but will be condensed in D and not pass up E, therefore; on the other hand, air will penetrate, in the opposite direction to the vapour, through C into A B, and will be carried away by the vapour blast. By this arrangement Gaede evacuated X-ray tubes in two hours. To accelerate the process the diaphragm may be made very large or very thin; but there is a theoretical limit—apart from the practical limit—to this simple view concerning the reduction of the thickness of the diaphragm; for theoretically the speed of evacuation should become infinite when the thickness is reduced to zero.

The porous diaphragm may be considered equivalent to a large number of openings of dimensions comparable to the mean free paths of the gas molecules on the kinetic theory. Calculating the rate at which a gas would diffuse in through a small hole in a thin plate, through which another gas or vapour is escaping in the opposite direction, Gaede found that the first gas would diffuse in at the maximum rate when the size of the aperture was approximately equal to the mean free path of the second gas. Thus we may substitute for the porous diaphragm C of Fig. 1 a narrow slot C made in the blast tube A B (Fig. 2). The tube A B is surrounded by the jacket D, kept cold by F;

* *Annalen der Physik*, vol. xlvi, page 357.

the mercury blast passing up A B and outward through C is condensed in D, whilst the air from the vessel to be evacuated flows in through E, D, C and up A B. That was the principle of the new pumps of Gaede and of Langmuir, the latter of which we illustrated in August. In introducing the novelty, Gaede had proved, by an investigation of the dynamical equilibrium between mercury vapour and dilute gases, that a mercury-vapour pump can indeed produce an exhaustion below the vapour tension of the mercury in the pump—contrary to the common belief.

The action of this pump depends upon two processes, the entrance of the air into the vapour blast, and the convection of the air molecules together with the vapour molecules of the blast into the condenser. The second action is that of the ordinary steam ejector, but the first action—the feed of air, so to say, is in the ejector not ascribed to diffusion, but to the lowering of the pressure caused by the high velocity of the steam jet. There

Fig. 3.

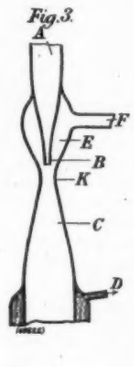
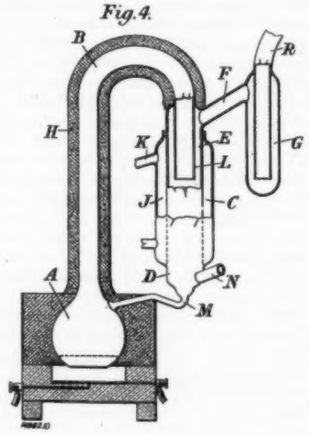


Fig. 4.

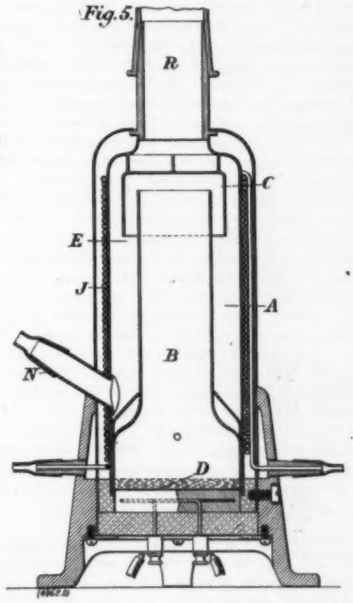


is not much difference really in principle in the first-mentioned distinction between the Bernoulli ejection and the Gaede diffusion; we do not quite agree with Langmuir on this point. But in practice things assume a different aspect; and Langmuir shows that the type of pump indicated in Fig. 3 could not produce a high vacuum if considered simply as an ejector. In a certain sense Fig. 3 is inverted; the vapour blast is supposed to pass down A B, escaping at B into C and into the cooled condenser D. The connection with the vessel to be exhausted is through E and F, and there is a stricture of E at K, an important feature. The mercury vapour escaping at B will strike the wall at K; the wall will become warm, the condensed mercury particles will re-evaporate again, as fast almost as they were condensed, and pass off in all directions; thus they will also travel up E and raise the gas pressure in the inrushing air. The pump should hence fail at very low pressure, and Langmuir found this to be so by experiment. When he prevented re-evaporation of the mercury by cooling the walls, not only at D as indicated, but also at K and C, a high vacuum was obtained, the speed of evacuation being 1,800 cub. cm.—and up to 4,000 cub. cm. with improved pumps—per second instead of 80 cub. cm. by the Gaede diffusion pump.

It may be objected that the mercury particles would be reflected at K as well as re-evaporated, and that cooling would not affect the reflection. But Langmuir—this is his novel point and the reason for his styling the pump a "condensation pump"—says that metallic vapours are *not* reflected from the walls they strike, and he sees in the action of his pump (and in the failure under the conditions mentioned) a proof of the correctness of his views. Some experiments with his first pump (see previous article) further confirm this view. That there is very little reflection of mercury vapour from a mercury surface was observed already by Hertz in 1882; M. Knudsen recently confirmed this in his careful determinations of the evaporation of mercury in a high vacuum. R. W. Wood found, in 1915, that when a stream of mercury atoms impinged upon a glass plate kept at a definite temperature, all the mercury was condensed on the glass at the temperature of liquid air, but when the plate was at ordinary room temperature, all the mercury seemed to be reflected diffusely. Langmuir* interprets this observation in a different way. He says that the mercury striking a surface is always condensed, and may be re-evaporated, but is not really reflected. From his researches on incandescent lamps he concludes that the atoms or molecules of metals (tungsten, silver, copper, nickel, platinum, &c.) which are emitted by hot filaments are not reflected by the walls of the bulb, whilst there is a certain amount of reflection (large in the case of hydrogen) of atoms of permanent gases, especially by adsorbed films of their own. We will not enter further into these considerations on the present occasion, but proceed to a description of the condensation pumps.

Fig. 4 illustrates the new pump as built of glass.

Fig. 5.



Mercury is kept quietly boiling in the flask A, whose long neck B is lagged with a thermal insulator H and ends in the nozzle L. Connection with the vessel to be exhausted is established through the tube R, (which is encased in the vapour trap G), and the tube F, which leads to the annular space E, where the mercury-vapour blast from L and the gas meet; C is the outer wall of E and is cooled by the jacket J, the upper outlet of the water at K being above the mouth of L. The condensed mercury flows down into the condenser D and through M back into the flask A; at N the rough pump is joined to the apparatus. In some of the pumps constructed the diameters of B and nozzle L were only $\frac{1}{4}$ in., in others up to $1\frac{1}{4}$ in.; the smallest pump had a total length of 4 in. only. With the size of the pump the speed of exhaustion increases. The temperature is so regulated (heating by gas or electricity) that the neck of B inside the insulation H keeps at 100 or 120 deg. C.; there is no critical temperature, however, as with the Gaede pump, and the speed of the exhaustion is, within limits, little influenced by the temperature; but the back pressure on the exhaust side of the pump at N, against which the pump may be operated—*i.e.*, the pressure in the "rough" pump, in series with which the pump works—depends upon the velocity and amount of mercury vapour issuing through the nozzle L.

The pump, Fig. 5, built of metal, is at least as simple as the glass pump. The metal cylinder A is connected at N with the rough pump and at R with the vessel to be exhausted. On the bottom of the cylinder, which is covered with mercury D, rests the funnel-shaped tube B, over the mouth of which is suspended, from the top of the cylinder A, the inverted cup C. The mercury vapour passes up B, is deflected by the cup C and, passing downward, is condensed on the inner walls of A, which are water-cooled by the coil J. The air comes down through R into the space E between C and A, and is removed through N; the condensed mercury returns into D through ports near the junction of B and A. A pump of this type, electrically heated as indicated, with a funnel B, 3 cm. in diameter, and a cylinder A, 7 cm. in diameter, gave a speed of exhaustion of about 3,000 cub. cm. per second, operating against an exhaust pressure of from 200 to 600 bars (dynes per square centimetre), consuming from 100 to 500 watts. With the smallest of these pumps, having diameters of B and A of 0.6 and 2 cm., the speed of exhaustion was 200 cub. cm.

As in the case of the Gaede diffusion pump, there is no lower limit of the exhaustion obtainable. A limit would be introduced by the diffusion of gas back from the exhaust side at N, against the mercury blast. But the blast of mercury vapour, Langmuir points out, is moving with a velocity as great at least as the average molecular velocity, so that there is little danger of leakage back; if it should occur, however, the pressure in the blast, or the distance against which the gas must pass back through the blast, can easily be increased. Under normal working conditions back-diffusion is said to be negligible. The condensation pump shares with other mercury pumps the inability, however, of removing mercury vapour from the gas to be exhausted. But the mercury-vapour pressure is only two bars at the ordinary room temperature, and by surrounding the gas trap G, in Fig. 4, with a freezing mixture (solid carbon dioxide or liquid air, *e.g.*), this vapour pressure can be further reduced. Making use of a new vacuum gauge, devised by Dr. A. W. Hull, of the same research laboratory, Dr. Langmuir has measured exhaustions down to 10^{-5} bar by means of his condensation pumps; and he hopes to carry the exhaustion further by the use of liquid air. This cooling also decreases the rate at which gases adsorbed by the walls of the vessels escape, and thus helps to improve the exhaustion.

One feature calls for special notice. The tube R connecting the vessel to be exhausted with the pump should, in the new pumps as in all high-speed vacuum pumps, be of ample diameter. Otherwise the flow of the gas through the tube meets with increasing resistance as the exhaustion advances. According to Knudsen, who investigated this problem in 1909 (*Annalen der Physik*, vol. xxviii, page 76), both theoretically and experimentally, the quantity of gas q flowing through a tube under the pressure gradient $p_2 - p_1$ is given by $q = (p_2 - p_1)/W\sqrt{\rho}$, where ρ is the density of the gas and W the resistance; this resistance becomes very great when the mean free path of the molecules is large compared to the diameter of the tube, and is proportional to the length and inversely proportional to the cube of the diameter of the tube; the formula also applies to the flow through small orifices. Thus at very low pressures only 0.001213 cub. cm. of gas would flow per second through a tube 1 cm. in diameter, 10 cm. long, which at ordinary pressure would allow 13.6 cub. cm. to pass. For high-speed evacuation (4,000 cub. cm. per second) a tube 30 cm. long should be at least 4.5 cm. in diameter. This feature was accentuated by Gaede when he introduced his molecular pump, and it will be noticed in Fig. 5 that the connection R of the condensation pump is very wide. From electrical analogy Langmuir proposes the term "impedance" for the product $W\sqrt{\rho}$.

* *Physical Review*, August, 1916, vol. viii, p. 149 to 177.

THE LATE MR. JAMES STIRLING.

As announced on page 55 *ante*, Mr. James Stirling, who was for 20 years locomotive engineer to the South-Eastern Railway Company, died on the 12th inst., at his residence, Doon, Ashford, at the age of 81. Mr. Stirling was born in Ayrshire, and was the youngest son of the late Dr. Stirling, of Galston parish church. He served his apprenticeship with Messrs. Sharp, Stewart and Co., of Manchester, and subsequently assisted his brother, Mr. Patrick Stirling, who was at the time locomotive

superintendent of the Glasgow and South-Western Railway, at Kilmarnock. Later, in 1866, he succeeded his brother in that position on the latter's appointment as locomotive engineer to the Great Northern Railway.

During Mr. James Stirling's period of service at Kilmarnock many improvements were carried out in the engines, carriages and wagons; one which afforded him great satisfaction was the introduction, in the year 1868, of cushions in the third-class vehicles. In those comparatively early days the journey between Glasgow and London was a very tedious one, and as the Settle and Carlisle Railway was not then opened, the only means of communication was by a "through" carriage, which joined the London and North-Western Railway at Carlisle. Mr. Stirling also introduced steam reversing gear on the engines of the Glasgow and South-Western Railway, a device which was greatly appreciated by the engine drivers. He was the first engineer to introduce in locomotive construction a design which included a leading bogie, four coupled wheels 7 ft. in diameter, and inside cylinders 18 in. in diameter with the valves between them. This type of engine was for many years a standard design for express passenger work in Great Britain, No. 6 being the first engine to this design.

Mr. Stirling was appointed locomotive engineer to the South-Eastern Railway, in succession to Mr. Cudworth, in 1878, and remained with that company until the end of 1898, when the amalgamation of the South-Eastern with the London, Chatham and Dover Railway took place; he then retired from active service. During the period he was on the South-Eastern Railway many improvements in the locomotive power on the railway were introduced by him; he also introduced the steam reversing gear which proved so successful on the Glasgow and South-Western Railway, with the result that nearly all the 700 engines on the South-Eastern and Chatham Railway are now fitted with that appliance. The company's locomotive construction shops were much extended, and the engines on the South-Eastern Railway system were increased in size and equipment to meet the growing demands of the traffic.

While Mr. Stirling did not take any very active part in the general affairs of the town of Ashford, he was a magistrate, and was regularly seen on the Ashford Bench. He was also a commissioner of taxes. When in Kilmarnock Mr. Stirling was hon. secretary to the Scotch Locomotive Railway Engineers' Association, and on his removal to Ashford, on the formation of the Association of Locomotive Engineers of Great Britain and Ireland, he was appointed hon. secretary of the latter body, a position which he filled with much satisfaction to the members, and only vacated when he retired from the South-Eastern Railway. As stated in our paragraph above referred to, Mr. Stirling was elected a member of the Institution of Mechanical Engineers in 1880, and of the Institution of Civil Engineers in 1886.

NOTES.

Luminescence Measurements.

Quantitative determination of the faint luminescence which is called fluorescence when it lasts only as long as the excitation, and phosphorescence when it persists after the excitation has been stopped, is very desirable scientifically, and has recently become of practical interest owing to the increasing use of self-luminous preparations containing radio-active excitants. Most photometric arrangements are unsuitable for the purpose, because the luminescence is faint and the area emitting the light small. We described the neat arrangement used at the National Physical Laboratory for testing luminous dials the other day in connection with our notice of the Optical Society's Exhibition, and we find in the Journal of the Washington Academy of Sciences, of January 4, 1917, a description, by Mr. N. E. Dorsey, of the apparatus in use at the United States Bureau of Standards. The apparatus consists of a photometer box, 2 or 3 m. in length, 25 or 30 cm. square, painted black inside, within which a small carriage supporting a small lamp (1.5 or 2 candles) runs centrally; the carriage is pulled by a cord, and its position is read off on a steel tape moving with the carriage. The front end of the box is closed by a screen of opal glass, 2 or 3 cm. square, which is backed by a colour filter, so chosen as to make the transmitted light match the luminescence. Movable black diaphragms in the box guard against any undesirable light reflections. The luminous material to be tested is either applied to a card or is placed in a small thin-walled glass tube which is painted black over two-thirds of its outer circumference. The card or tube is placed against the screen, the unpainted part of the tube facing the observer, and the tube is then turned so as to reduce the visible dark edge on one side to the smallest amount consistent with screening the opal glass; the observer's line of sight should be normal to the screen. The carriage is then moved until the tube disappears on the screen. If the lamp be then at 70.5 cm. from the screen, and the surface brightness of the screen be 3.96 microlamberts, the specimen will have a surface brightness of $3.96 \times 1.38/0.705^2 = 11$ microlamberts, 1 microlambert being the brightness of a perfectly diffusing and completely reflecting white surface when illuminated by a source of unit candle-power at a distance of 10 m. The factor 1.38 in the calculation is the candle-power of the tungsten lamp used, when burning at the colour of a 4-watt carbon lamp, in the direction of the length of the photometer. As in all photometric measurements, the eye should be in a sensitive state, to ensure which the observer should, in these delicate tests, have remained in complete darkness for at least 15 minutes. The material must be protected from all external light for several hours before the test. Another error especially to be guarded against is the Purkinje effect. This effect concerns the influence of colour on our judgment of brightness. Two adjoining luminous surfaces which appear of equal brightness when seen at a certain distance will no longer appear to be equally bright when viewed from a different distance, and this effect is very pronounced at low intensity. When there is practically no colour sensation at low intensity, the colour match should be made by spectroscopic examination. When the luminescence consists of a number of narrow bands scattered over the visible spectrum, the Purkinje effect makes an exact colour match very difficult. For cases in which there is only one broad band, this photometer can be improved by the addition of a phosphoroscope and a constant source of illumination.

Schemes for Apprenticeship Education.

We are glad to note an increasing consensus of opinion in favour of some scheme whereby apprentices will be able to attend part-day classes on two or more days per week while serving their "time," provided they prove worthy of the privilege. This was one of the proposals put forward by Sir Trevor Dawson in his address to the Association of Technical Institutions, and dealt with in our issue of October 27 last (page 414). This, too, was the dominant note in the paper on the education of apprentices to engineering and allied trades read on the 24th inst. at the Liverpool Engineering Society by Mr. Tom R. Thomas, B.Sc. He contended for compulsory classes for apprentices. An interesting feature was the narration of details and schemes of this nature by the prominent engineering firms. At the Walker shipyard of Messrs. Armstrong, Whitworth and Co. apprentices are encouraged during the term of their apprenticeship to attend classes which are held at the works on two afternoons each week. For proficiency and successful results in the examinations held periodically the apprentice is awarded a bonus ranging from 2*d.* to 6*d.* per week, according to results. This increase may be obtained each year of attending the classes. The instruction is given in the works and during working hours, and the school consists of two class-rooms, one of which is fitted up for practical and laboratory work. All fixtures have been supplied by the firm, but the furnishings and apparatus are supplied by the Newcastle Education Committee. The classes run for 40 weeks in the year, and the hours of instruction are from 2 o'clock to 5 o'clock. This is divided into two portions of 1½ hours each. In reports issued on the work done, it is stated that, "on the whole, the classes are doing satisfactory work." The numbers in attendance when the classes were started in September, 1915, were 36 first-year and 31 second-year students. The greatest difficulty is to persuade the boys to take up the classes. In the firm of Messrs. Vickers, Limited, Barrow-in-Furness and Erith, an examination is held, upon the results of which apprentices are admitted to the works. At the Erith works this examination is of a fairly advanced character, including English, mathematics, physics, mechanics, descriptive geometry and machine drawing, the minimum requirement being the equivalent of the second-year course in engineering science at the Erith Technical Institute. All the apprentices are under the supervision of a superintendent of apprentices, who is responsible for their theoretical and practical training. Diligent students receive permission to attend afternoon classes during the winter session in the last two years of their apprenticeship, the time being counted as time worked with pay. A mechanical instructor devotes his whole time to assisting the apprentices in the various shop courses. Extra pay is awarded on the results. Messrs. Harland and Wolff, of Belfast, permit apprentices to attend day classes for one whole day during the week, provided that the apprentice is regular in his attendance both at the classes and at work. Several firms allow their apprentices to "sandwich" a college day course with their apprenticeship, and offer several other inducements to their apprentices to attend the ordinary evening classes. In the case of Messrs. Cammell Laird and Company, when the student has reached a certain stage, at which he is capable of attending a technical course, he is allowed to enrol under a bonus scheme. He attends the usual courses in subjects suited to his particular trade, and receives an addition to his wages of either 1*s.* or 2*s.* per week, according to the results he has obtained in his examination and to the reports of the education authorities. This has proved a considerable inducement, and there is a great deal of keenness shown among the apprentices to earn this addition to their pay.

Trading with the Enemy Act.—The Controller of the Foreign Trade Department has sent us a copy of a new list of additions to the Statutory List of firms of enemy nationality or enemy association with whom persons in the United Kingdom are forbidden to trade. Copies of this list can be obtained at a trifling cost from the Superintendent of Publications, H.M. Stationery Office, Imperial-house, Kingsway, W.C.

Magnetos.—When war broke out there was only one British firm making magnetos, its output being under 100 a week. Practically every magneto which went on to the motor vehicles, motor boats and aircraft of Great Britain came from Germany or from America. To-day there are some twelve or more British firms making magnetos. Their entire output, reaching a total to date of over 165,000 magnetos, has been made for war purposes, the magnetos being used on aeroplanes, seaplanes, airships, motor lorries, motor ambulances, motor cycles, "tanks," big-gun tractors, motor boats, wireless sets, searchlight sets, lighting sets, &c.

"The Royal Navy List, or Who's Who in the Navy."—This publication, by Messrs. Witherby and Co., 326, High Holborn, London, issued at the price of 10*s.* net, should be particularly acceptable at the present time, when the deeds of our brave seamen appeal with so much fascination to the intelligent reader, because there is given a bibliographical sketch of all officers in the service, as well as a record of the war service of all and of awards due to valour. There is reproduced, too, a diary of the events of the war so far as the Navy is concerned, with a copy of Admiral Jellicoe's despatch on the Battle of Jutland. The life story of every ship of the Navy is given, so that it will be seen that a really intelligent study of the war is advanced by the possession of a copy of this work.

"Jane's Fighting Ships, 1916."—This encyclopedia of the navies of the world, now in its 19th year, has just been issued by Messrs. Sampson, Low, Marston and Co., Limited, at the price of 21*s.* net. This book has now a world reputation as a standard work, due to the originality, and extreme care to ensure accuracy, of its founder, Mr. Fred. T. Jane, who died since the last issue, and of whose career a brief notice very properly forms a feature of this year's issue. In the previous volume all reference to the British Navy was prohibited, but this year the editor has been permitted to publish once again all the data with reference to the ships composing the British fleet before the outbreak of the war, but without the silhouettes or illustrations which have always formed a characteristic feature of the volume. In the case of all foreign navies, however, there are still given the fullest and latest data as to the characteristics of design of all ships, along with illustrations and silhouettes, but obviously particulars regarding ships of the belligerent fleets are necessarily incomplete. The charts of all naval harbours form a serviceable part of the book, while the record of all ships lost in the war will be found useful for reference.

THE INSTITUTION OF MECHANICAL ENGINEERS.

AN ordinary general meeting of the above Institution was held on Friday last, the 19th inst., at the Institution of Civil Engineers, Great George-street, Westminster, the chair being occupied by the president, Dr. W. C. Unwin, F.R.S.

ELECTION OF OFFICERS.

The minutes of the previous meeting having been read, the announcement was made that, in accordance with article 23 of the Institution, the president, two vice-presidents and seven members of council would retire at the ensuing annual general meeting. The complete list of those retiring was as follows:—As president, Dr. W. C. Unwin, F.R.S.; as vice-presidents, Dr. Edward Hopkinson and Mr. Mark H. Robinson; as members of council, Dr. Dugald Clerk, Sir A. Trevor Dawson, Sir Robt. A. Hadfield, Messrs. Geo. Hughes, Robert Matthews and D. B. Morison, and Sir Gerard A. Muntz, Bart. The following had been nominated by the council with their consent:—As president, Mr. Michael Longridge; as vice-presidents, Dr. Dugald Clerk, Sir Robert A. Hadfield and Mr. Mark H. Robinson; as members of council, Sir A. Trevor Dawson, Messrs. Geo. Hughes, Robert Matthews and D. B. Morison, and Sir Gerard A. Muntz, Bart. The following nominations had also been made by the council for election at the annual general meeting, with the consent of the nominees:—As members of council, Mr. William Reavell, of Ipswich; Mr. David E. Roberts, of Cardiff; and Mr. Richard Williamson, of Workington.

The secretary pointed out that the nominations were renominations, with the exception of three, and in connection with these three names he would state that Mr. W. Reavell, of Ipswich, had been a member of the Institution since 1907; Mr. D. E. Roberts, of Cardiff (frequently present at the meetings), was elected in 1903; Mr. Richard Williamson, of Workington, was elected in 1883. Mr. Williamson was the donor of 500*l.* for research, as had been previously announced to members. He and his brother were shipbuilders at Workington, and together they had given 1,000*l.* for research, the 500*l.* given by Mr. Richard Williamson being for research to be carried out by the Institution of Mechanical Engineers.

As no member availed himself of the privilege, under by-law 26, of adding to the list of nominations, the president declared the list given above to be the list of nominations for election at the next annual general meeting.

The secretary further announced that the council had, at the council meeting held that afternoon, made seven transferences from the class of associate member to that of full member.

MANUFACTURE OF GAUGES.

The paper set down for reading and discussion was one entitled "The Manufacture of Gauges at the L.C.C. Paddington Technical Institute," the authors being Messrs. A. G. Cooke, M.A., W. J. Gow A.R.C.S., and W. G. Tunnicliffe, the latter an associate member. The paper, which we publish in full elsewhere in our present issue, was read, in substance, by Mr. A. G. Cooke.

Mr. Cooke, at the close of his summary, directed the attention of members to a drawing (Fig. 1, annexed) showing diagrammatically the fairly satisfactory arrangement devised to overcome the difficulties attendant upon projection. The arrangement was, he said, really equivalent to a microscope with an object glass and an eyepiece. Great improvement had been effected by the use of a lens of considerably larger diameter than that originally employed. He might explain that ordinary trade lenses could be adapted exceedingly well. The lens used was a Petzval lens (such as used for cinematograph work) of 3-in. focus, so that generally the screw was 3 in. away. The light directed upon the screw was a beam of absolutely parallel rays produced by the introduction of a suitable lens between the source of light and the screw. These rays would fall upon the combination shown, and the effect of the large-diameter lens was to converge the light and give a primary convergence. The speaker afterwards used an ordinary astigmatic lens, of about 6-in. focus. This would give a very rapid divergence of the rays, and would show, in a distance of 5 ft., a perfectly sharp image, as sharp as could be seen by the eye, therefore within easy reach over an area of about 30 in. in diameter. This enabled several screw threads to be taken off, and a perfect gauge could be obtained and could be fitted and examined, so as to be corrected to a standard drawing upon the screen. The large lens in front of the astigmatic lens was used independently. He might be justified in explaining that it was used at the National Physical Laboratory, but had been used independently by the L.C.C. Paddington Institute, for low magnification over a considerable area or through a considerable length. With the two lenses together he was able to get the high magnification, with extremely satisfactory results. Of course the question of focusing had to come in, and the necessity of getting a parallel beam of light, so that a really pure shadow was produced on the screen.

The results described in the paper had been obtained by working this optical apparatus very closely in conjunction with a lapping device (Fig. 2). The difficulty with the lapping device, as with all mechanisms run at high speed, was that a knock was sure to be developed, and it was very difficult to get smooth running at the very high speeds required.

Fig. 1.

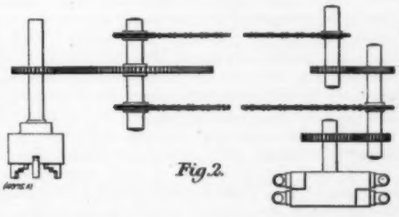


Fig. 2.

He had introduced a simple arrangement, with which was obtained a direct drive upon the axle of the motor itself, so that no machinery or anything disconnected could cause knocking. The drive forwards and backwards could be made, through any prescribed distance, with great precision by the simple device of reversing the switch by the motor itself. The motor ran sparklessly, and acted as an electrical brake to pull itself up almost precisely as a piston was pulled up in a cylinder by compression. The arrangement was simply that a secondary shaft was introduced, which was geared down, and two free wheels (the ordinary free-wheel mechanism of a bicycle) were used in opposite directions, these being connected up with two other shafts, linked together in the same way. It would be seen that whichever way the motor shaft was going, backwards or forwards, the other shaft would continue to go steadily forwards. In other words, the device was a mechanical rectifier; whether driven through one free wheel or the other the rotation would go forward uniformly. The last shaft drove a commutator of suitable design. This commutated the armature of the motor, so producing a machine which would run rapidly backwards and forwards. He could, in a few moments, make the backward and forward motion in any number of revolutions, simply by altering the pinions.

The President, in proposing a vote of thanks to the authors, observed that the subject of the paper was one of the greatest importance at the present moment. The production of gauges had been a very difficult matter to tackle, and he feared that the difficulties incidental to getting the gauges of the accuracy required were not yet at an end.

Mr. E. M. Eden, of the National Physical Laboratory, then exhibited a series of interesting slides illustrating work done at the Laboratory. As it would be quite impracticable to reproduce the very numerous slides shown, we content ourselves with extracting from Mr. Eden's explanatory remarks the following general observations. Mr. Eden desired, in the first place, to congratulate the authors of the paper, which recorded an excellent piece of work done under great difficulties. The method of altering the change wheels in a lathe in order to correct a very small error in the pitch of the leading screw was of great interest. He was unaware of any application of that method at the National Physical Laboratory. It might be interesting to members if he showed some of the measuring machines and methods in use at the National Physical Laboratory, and, in that relation he might say a word or two as to the policy of the gauge-measuring staff at the National Physical Laboratory. In measuring large quantities of gauges the simple method was to place those considered to be right in one lot and those regarded as wrong in another. Unfortunately, that did not meet the case of the difficult gauges, particularly screw gauges. A manufacturer desired to know more than the mere statement that the screw was too rough, as that would not assist his endeavour to improve his gauges. It had been the practice, in the case of difficult gauges, to measure every gauge, with all its elements. This course introduced such a large amount of work as to necessitate improved and more rapid methods of measuring, equally as valuable to the manufacturer as to the Laboratory. It had also been the practice at the Laboratory to do such work and, at the same time, to assist the manufacturers as far as possible. The latter were welcome visitors at the National Physical Laboratory, and the methods in use were explained to them, while the various machines and apparatus were freely offered to them for use in any way they chose, together with drawings and such other assistance as it was possible to render.

With regard to pitch errors in the leading screws of lathes, the Laboratory had, in the early days, set out to assist the manufacturers in getting their leading screws correct. A manufacturer wishing to get a good screw would cut trial screws on the lathe and send these to the Laboratory, which would issue reports on their accuracy or otherwise and suggest methods of improving the lathes and getting over the errors. That, also, was done at the Paddington Institute, Figs. 2 and 3 in the paper being illustrations in point. The curves were taken from National Physical Laboratory reports (the first in November, 1915) on certain screws from Paddington which had the errors indicated. The second diagram was taken from a National Physical Laboratory report of April 4, 1916, the great improvement as between the two being caused by the introduction of the methods of correction described, in regard to the progressive error, and, in respect to the periodic error, by the ball thrust bearing, the standard method recommended by the Laboratory. The arrangement for effective diameter measurement, shown by Fig. 4 of the paper, was introduced in the autumn of 1915, for measuring core and effective diameters of screws. The older method had been found too slow and greatly more difficult.

The speaker then threw various diagrams on to the screen to indicate the supersession of the older by more modern methods of measurement, such, among others, as the abandonment of the "three-needle" micrometer in favour of the "two-needle" type. He also called attention to the accuracy of the Brown and Sharpe micrometer, and referred, in the case of a particular instrument, to the Laboratory practice of making the necessary corrections beforehand, by setting up against a standard. In another instance the method of projection in use at the Laboratory was illustrated, the speaker taking occasion to remark that many people had considered it very difficult, if not impossible, to project the image of a screw, in the way indicated, with any degree of accuracy

on account of distortion. A difficulty in the case of optical projection was in the selection of the right lens to use. For certain purposes the best lens he had met with was the Dallmeyer portrait type of lens.

Mr. W. H. Booth remarked that the subject of the paper was of extreme interest and was one which should have been dealt with 20 or 30 years ago. He had also found it interesting to observe how men who knew nothing about gauges, flat or screw, had risen to the occasion during the past two years. The technical institutions in London had also done exceedingly well, to which fact the paper under discussion bore witness. Much of the work that had been done should, however, have been unnecessary. No man could make a screw gauge accurately unless he had an accurate leading screw. At the National Physical Laboratory a large leading screw, made for a special purpose, was corrected for inequalities until its degree of accuracy fulfilled that purpose. Every manufacturer of machines requiring leading screws should have in his possession a leading screw which was accurate. Had such methods been adopted 20 years ago, this country would not have been assailed in the way that it had been, and would have been better prepared to meet the necessities of accurate mechanical construction than was the case when the war began.

Mr. P. A. Bentley inquired whether there was any secret in regard to the lap used. [In reply, he was informed that there was no secret in the matter. Everything depended upon the part of the gauge which required lapping, whether effective diameter or core diameter, &c.] Mr. Bentley continued with the remark that there must be other methods of carrying out the lapping in which the operation would be under supervision during the whole of the time, and also under measuring supervision. From what he knew of screw-gauge lapping, the work was all done on the same process, which he did not regard as a satisfactory process; the object might be achieved, but he thought there were better methods to be adopted.

Mr. H. Ade Clark observed that he could only speak on questions of principle and practice in relation to cylindrical gauges, both the plug gauge and the ring gauge; whereas the paper was almost confined to consideration of the screw gauge. He desired, however, to submit two little developments which he had carried out to facilitate measurement during manufacture. When a man was turning, grinding and perhaps lapping an ordinary cylindrical gauge, he would, if allowed, constantly use a micrometer, damaging the latter, both on the table and in the screw, so that it became necessary to treat it simply as an auxiliary measuring appliance, checking the work very closely later on. Speaking more particularly of the manufacture of ring gauges, where it was difficult to use a micrometer for direct measurement, the difficulty had been avoided by using the instrument referred to, which constituted an indicator rather than a measurer. A micrometer was set up in a stand to the dimensions required in, say, a ring gauge, and then, by gauging between the micrometer points by a small indicator having a pair of ball points, and transferring this indicator to the work, it was possible to observe whether the indications given by the appliance in the two cases were in agreement. In that way, it was practicable to lead up as near to the required dimensions as the appliance would indicate. Recently the works had made 25 cylindrical gauges about 2 in. in diameter and 2 in. long. That involved a good deal of careful work, and it might be thought that standard plugs would have been necessary for checking the gauges; not a single plug, however, had been made for that purpose. The gauging was done entirely with the little sliding indicator described, a simple shop-made instrument. He hoped to submit a drawing of this instrument to the Institution. In the case of the 25 gauges mentioned, three had been returned from the National Physical Laboratory for readjustment; they were merely a little too small; that evidenced the satisfactory character of the method.

Dr. Garnett, who spoke next, said that he, like others, had been much interested in observing how the unskilled worker had risen to the occasion in the matter of accurate work, not only to the first, but to the second, and even the third, order of "small quantities." With regard to institutions, he believed that more than 100,000 gauges had been made in educational establishments in England alone during the last 18 months. He desired to ask Mr. Cooke whether, in the apparatus for measuring the pitch of screws, it would not be better to have the bar to which the clamps were attached of a rectangular form—say, 2½ in. deep and ½ in. wide—instead of circular. It appeared to him that the setting on the circular bar was apt to give a slight cant to the clamp, so putting a strain upon the sliding bar, and involving unnecessary friction; the latter could be prevented if the clamps were fixed upon a rectangular bar of considerable depth. He expressed himself as greatly pleased with the apparatus for producing the reversing motion of the motor for lapping the screw threads. At first sight, the use of an electric motor making half-a-dozen turns in one direction and then half-a-dozen turns in another, quite automatically, while the commutator was running in the same direction, seemed rather puzzling. He rather wondered whether the lapping arrangement would produce an accurate thread when the periodic error was an exact turn of the thread, or when the periodic errors appeared for an integral number of times in one direction. It appeared to the speaker that possibly in this case the lapping arrangement would simply follow the thread. Taking the case given by Mr. Cooke, in which a screw of 14 threads to the inch was cut from a leading screw with 4 threads to the inch, any periodic error in the leading screw would be repeated every 3½ threads upon the screw being cut. There would, therefore, be errors on opposite sides of the cylinder alternately. The lap, gripping, as it did, some half-a-dozen threads, tended to produce a screw which would be the mean of all the threads, and when the errors were alternately in one direction and the other, the mean would be the accurate thread. But when all the errors were in the same generating line, in the same direction upon each thread, it seemed to him that the lap might follow the errors, and not give any considerable increase in the accuracy of the thread. Turning to another point, the authors, in discussing the nature of manufacture, had observed: "Hence the apparent paradox that high accuracy in the inspection gauges allows more laxity, and so increases facility and speed of manufacture." The speaker had difficulty in understanding how high accuracy in the inspector's gauge permitted greater freedom in the manufacture of the article. He supposed that, inasmuch as the tolerance of an inspector's gauge was always outwards, plus on the H and minus on the L, the high accuracy indicated by Mr. Cooke depended upon the assurance that that tolerance should always be outwards.

Mr. A. G. Cooke then replied to that part of the discussion which concerned him. He desired, in the first place, to refer to the apparent paradox commented upon by Dr. Garnett. He had not intended to convey the meaning suggested by Dr. Garnett. If we could obtain a supply of gauges rapidly and in sufficient quantities with a tolerance reduced to one ten-thousandth instead of three ten-thousandths, it would then be possible to leave a wider margin in the limits which the gauges had to define. There would be a good deal more margin left to the manufacturer, who had to work within those limits. With regard to lapping on an integral number of turns, the speaker's idea had been to get high speed, so that to some extent inertia would come in. The motor was now working at 300, 400, and as high as 500 r.p.m., backwards and forwards, but he hoped to increase this speed by improved methods of construction. It seemed natural that high speed should be wanted, and also that the period should be short. Certainly it would be better if the relation between the number of screw threads on the gauge and that on the leading screw were not in simple proportion. It was not altogether well to cut the screw thread to, say, 24 to the inch when the number on the leading screw was 12; it would be better to have a leading screw with 14, because the periods would not be likely to agree with those of the threads In regard to the question of supervision, the speaker did not think he had made it clear that the part of the work which he regarded as most successful was the operation of lapping in conjunction with high-power enlargement by optical projection. As he had said, it had been possible to get 163 magnifications right alongside, and the projection took place at a range of only 5 ft. away, a very different thing to working across a room; great pains also were taken to reduce this distance. The gauge was simply put in a chuck, and was lifted out and dropped into the bearing in a moment, so that the shape was projected on the screen. Three laps were used, one for the crests, one for the sides and another for the core. Moreover, there was control by direct measurement of the diameter, so that the supervision, when lapping down, was really close, especially as to shape. Referring to Mr. Booth's allusion to the accuracy of leading screws, the method employed by the speaker overcame a great many difficulties in the hardening of the screw gauge. With a precision lathe the screw could be cut with absolute correctness, but with hardening (unless there were methods in use which were a great improvement on any known to the speaker) distortions were bound to occur. Lapping, which worked equally well with the hardened gauge, was a process which ought certainly to receive a good deal of consideration. It was all very well to construct a perfect screw thread in the cutting, but what would take place during hardening? He had hoped that this matter would have been mentioned in the discussion. Mr. Eden had contributed much to the discussion, but while desirous of giving credit to the National Physical Laboratory for all that they had done, he (the speaker) would have been glad if Mr. Eden had taken some notice of the method of projection with the double magnification. The introduction of the extra large lens had enabled the speaker to cover a very much wider field. The speaker had largely imitated a microscope, to get the equivalent of a lens of about ½-in. focus, and yet be able so to place the screw gauges, of fairly large diameter, so that they would be a few inches away. With a Dallmeyer cinema portrait lens as objective, and a wide angle combination as eye-piece (Fig. 1), high magnification with critical definition was secured without long-distance projection. Reduction of diffraction, freedom from vibration, and general convenience demanded a short distance of screen. The eyepiece combination, he explained, was used independently, as at the National Physical Laboratory, for considerable lengths of gauge (particularly flat gauges up to about 2 in.) placed close behind the larger lens. As he had said, with parallel light operators were limited to the actual diameter of the lens; the light not converging in any way, it was only possible to use an area equal to that of the lens itself. This provided an effective and very good system, with high magnification. In this way as fine a line as could be seen by the eye could, with care, be obtained. A skilled man could, of course, work with 50 magnifications, but naturally preferred a bigger object. A ten-thousandth of an inch was equivalent to a sixty-fourth on the screen, and it was much easier to be sure when working to that than when the magnitude was two-hundredths of an inch.

Mr. W. G. Tunnicliffe replied to the questions raised as to lapping. There might, he admitted, be other ways of cutting a screw gauge when the steel was soft. In that case the speaker would employ a tool specially formed for cutting correctly the core diameter and effective diameter. When, however, a hardened screw gauge had to be dealt with difficulties arose. The effective diameter would probably come up in size, while the pitch would probably, in fact, generally did, lengthen. The core diameter might come up by a small amount or might not exceed limits. It might be necessary to lap two or three ten-thousandths of an inch off an effective diameter and one ten-thousandth off a core diameter, in the case of a hardened screw gauge. At the Paddington Institute they were engaged on the very difficult task of lapping hardened screw gauges, a task particularly troublesome in the case of standard gauges, where the maximum limit was three ten-thousandths of an inch. He did not think there was any difficulty in lapping plain cylinders, especially if ground after being hardened. In such cases he generally used a copper or a lead lap. A lead lap held more abrasive than a copper lap.

Mr. W. J. Gow said that the remarks made by

Mr. Eden might give an impression that the correction of periodic error in the lathe referred to in the paper was due to the application of the ball bearing at the end of the leading screw. As a matter of fact, however, trial screws, cut before and after the application of the ball, showed exactly the same amount of periodic error. The cause finally proved for the periodic error was that referred to in section (3) of the paper. After a new leading screw had been produced, it was discovered that there was a certain amount of whirling of the leading screw, which was attributed to lack of straightness or stiffness, causing oscillations at the point of contact of the nut. After the introduction of a stiff shaft, on which was mounted the leading screw cut on a milling machine, a periodic error within limits was obtained. On the question of hardening of gauges, it had been suggested that while the result of hardening was to increase the pitch by, say, eight ten-thousandths of an inch, as an extreme value, it was easy to allow for that by cutting a screw which was short in pitch by this amount, and, provided the same heat treatment was applied to it as had been applied to the trial screw, a hardened gauge of the correct pitch would, in the end, be obtained. The problem was not quite so simple. He had found that, in hardening screw gauges, the diameter at one part of the screw might prove to be very much greater than at another part, while in some cases the size would go down. Mr. Tunnicliffe had recently carried out some interesting experiments in the case of an ordinary screw gauge, with a handle at one end approximately half the size of the screw; the other end of the screw was plain. Without taking any special precautions, it was found that the threads at the ends of the gauge were larger in diameter after hardening and the diameter at the centre of the gauge was smaller. In one gauge the diameter of the screw at the plain end of the gauge increased in size by ten thousandths of an inch, while the diameter of the screw next to the handle end increased in size by seven thousandths of an inch, the diameter of the centre of the screw diminishing by three thousandths. The conclusion arrived at was that the extra cooling surface supplied to the outside threads by the ends of the gauge caused a greater rate of cooling at the temperature of recalescence of the steel than was obtained near the centre of the gauge. Another gauge was, therefore, tested, the ends being covered up, so as to prevent contact with the cooling medium, and it was found that the diameters of the screw threads through the whole length of the gauge were perfectly constant. He could not give the reason for larger diameters at the end with contracted diameters at the centre, but, personally, he related it to the internal strains set up. His institute had produced many satisfactory hardened screw gauges, and although much remained to be done, he felt confident that if the order came to produce hardened gauges, the difficulties would be overcome.

The president announced that the paper would be read at Leeds on the 24th inst., and at Birmingham on the 25th inst. Further, he intimated that the annual general meeting of the Institution and the election of officers would take place on February 16 next. The proceedings were then closed.

MACHINERY USERS' ASSOCIATION.—Speaking at the annual general meeting of this association in London, on December 19, the president, Sir Algernon F. Firth, Bart., J.P., said that the influence of the association extended to upwards of 7,000 firms, embracing a considerable majority of the most important industrial undertakings in this country. The association dealt not only with questions affecting manufacturers locally, but affecting them in Parliament also; it was thus of double value to its subscribers. He then gave a brief historical sketch of the association, and put forward a number of points illustrating the usefulness of the latter, especially at the present time of great industrial activity.

ALMANACKS AND CALENDARS.—We have received from Messrs. E. T. White and Co., engineers, Windsor House, Kingsway, a desk pad, containing an almanack for the year, with space for notes.—Messrs. G. F. West and Co., structural engineers, 13, Victoria-street, S.W., have sent us a glass paper-weight with which is combined a perpetual calendar; and Messrs. Stewarts and Lloyds, Limited, London, Birmingham and Glasgow, a very neat desk almanack.—Calendars and Almanacks have also come to hand from Mr. George Ellison, electrical engineer, Birmingham, London and other cities; from Whitehead Aircraft, Richmond; and from the Submarine Signal Company, Friars House, New Broad-street, E.C.

THE PHYSICAL FEATURES OF ADAM'S BRIDGE.

*On the Physical Features of "Adam's Bridge" and the Currents across it, considered as affecting the Proposed Construction of a Railway connecting India with Ceylon.**

By FRANCIS JOHN WARING, C.M.G., M.Inst.C.E.

THE introductory paragraph refers to the importance, magnitude and difficulty of the work, and points out the circumstances in which its early commencement may perhaps be looked for. A brief description of Adam's Bridge, in which reference is made to the islands at both ends in extension of it, and their geographical position, then follows, and it is pointed out that they suggest the only practicable route for the connection by land between Ceylon and India, and also divide the channel separating these countries into two parts. The southern part of this channel, which is of great depth, is briefly described, as well as the northern part, which is very shallow.

It is then stated that the whole of the channel is subject to the monsoons, a brief reference to which and their effect in causing an alternating maximum difference of 18 in. in the water-levels on the two sides of Adam's Bridge, is then made. A more detailed description of Adam's Bridge follows, in the course of which it is remarked that the channels between the sandbanks forming its crest are sometimes of great depth and the current through them is at times very rapid. It is further explained that none of these channels is navigable for vessels of any size, their approaches being closed by bars. Reference is made to the range of the tides. The narrow channels dividing the islands at each end of Adam's Bridge, from India and Ceylon, are then described.

Finally, the various proposals for constructing a railway between Indian and Ceylon are mentioned, illustrations of them and of the various surveys made of Adam's Bridge being given; and the paper concludes by stating certain possible objections to one of the latest schemes.

PERSONAL.—Mr. S. E. Bastow, who for the last four years has been joint manager of Messrs. Bruce Peebles and Co., Limited, Edinburgh, has accepted the position of chief engineer to British Dyes, Limited. Mr. Bastow's headquarters will be at Huddersfield. Mr. John H. Bunting, who for the last four years has been joint manager of Messrs. Bruce Peebles and Co., Limited, Edinburgh, has been appointed general manager of the company.—Mr. Charles Haswell, Sherbrooke Chambers, 8, Norfolk-row, Sheffield, has been appointed the agent of Messrs. Crompton and Co., Limited, London and Chelmsford, for Sheffield and the surrounding district.

AGRICULTURAL IMPLEMENTS FOR FRANCE.—A conservative estimate has just been published showing the extent to which agricultural material will be needed in the Northern and North-Eastern regions of France when they are freed of the invader. It is expected that they will require something like 35,000 ploughs, 52,000 harrows, 28,000 rollers, 15,000 drills, 20,000 reapers and binders, 14,000 mowing machines, 7,000 hay-making machines, 7,000 horse rakes and 3,500 threshing machines. Thus the task of re-establishing agriculture in these districts will involve an enormous sum. The figures serve to illustrate the need for all the help which the Agricultural Relief of Allies Committee (16, Bedford-square, London, W.C.) can offer, especially as the Committee hope to give some assistance on behalf of British farmers in the restoration of agricultural activity in all the invaded countries of our Allies when the enemy is driven off. The committee therefore ask for the hearty co-operation of all agriculturists in fulfilling our obligations to the peasants of Belgium, Serbia, and Poland, as well as of France.

SHIPPING, ENGINEERING AND MACHINERY EXHIBITION.—It will be remembered that a large International Shipping, Engineering and Machinery Exhibition was arranged to be held at "Olympia" in September and October, 1914, but the outbreak of the war necessitated its postponement until 1917. Owing to the continuance of the war and other causes, the company under whose auspices the exhibition was to have been held is now being wound up, but at a meeting of exhibitors held on the 23rd inst., Sir Archibald Denny, Bart., in the chair, it was unanimously resolved to accept a proposal of Mr. F. W. Bridges, one of the organisers of the exhibition (who is well known as having been associated with the organisation of London engineering exhibitions during the past few years) to form a new company, for the purpose of carrying on the exhibition, the new concern to take over all contracts with exhibitors exactly as they stand at the present time, the exhibitors not being called upon for any further payments beyond the original amount contracted for. Mr. Bridges' scheme also provides for the formation of an exhibitors' committee of twelve, representing both British and Dutch exhibitors, to act with him as organiser. Dr. Bisschop, chairman of the Dutch Royal Commission appointed in connection with the exhibition and chairman of the Dutch exhibitors, expressed his approval of the proposed arrangements and promised hearty support and co-operation on the part of the Dutch exhibitors. It was decided that the exhibition, which would be open for a period of three weeks, should be held at the first suitable date when "Olympia" is available after the war, the actual date to be decided by a majority of the exhibitors' committee.

* Abstract of a paper read before the Institution of Civil Engineers, on Tuesday, January 23, 1917.

COAL PRODUCTION IN CANADA IN 1916.

THE Dominion Department of Mines has received from the principal coal operators in Canada returns of their production for 10 months, supplemented in most cases with estimates for November and December. On the basis of the record available, it is estimated that the total production of coal in Canada during the calendar year 1916 will approximate 14,365,000 short tons (equivalent to 12,825,892 gross tons). The estimate is believed to be fairly close for Nova Scotia and British Columbia. In Alberta, however, there are so many small operators that final returns may show a wider variation from the estimates now made.

By provinces, the estimate is as follows, the figures for 1915 being included for comparison.

Estimated Coal Production in Canada, 1916—in Short Tons.

	Production of Coal.		Increase or Decrease.
	1915.	1916.	
Nova Scotia	7,463,370	6,950,000	− 513,370
New Brunswick ..	127,391	135,000	+ 7,609
Saskatchewan ..	240,107	260,000	+ 19,893
Alberta	3,360,818	4,400,000	+1,039,182
British Columbia ..	2,065,613	2,620,000	+ 554,387
Yukon	9,724	—	—
Total	13,267,023	14,365,000	+1,097,977

The 1916 production exceeded that of the two previous years, the increase over 1915 being about 8 per cent. Nova Scotia is apparently the only province that has not made an increased production, the falling-off in this province being a little less than 8 per cent. The increase in Alberta is nearly 32 per cent. and in British Columbia nearly 27 per cent. The production in New Brunswick, Saskatchewan and British Columbia is the highest on record. No estimates are available yet as to the Yukon output.

DISPOSAL OF WASTE TINS AND SCRAP.—The borough of Hornsey have put down a furnace for dealing with waste tin and scrap. It is heated by the destructor flue gases, and is arranged in such a way that the work is being satisfactorily carried on without increasing the staff engaged on the old processes. In the result the council were able to enter into a contract, as from October 1 last, for supplying, at advanced prices, to Messrs. Levin, Webb and Co. pressed de-tinned scrap, galvanised scrap, light waste, and solder. The whole process of preparation, including refining of the solder, being carried out by the town council's staff. From the first three months' working it is evident that the decision to deal with the work in this way has been fully justified, as the annual receipts for 194 tons will amount to £203. It will be noted that, notwithstanding the difficulty in disposing of the waste metal, the destructor yard has throughout been kept clear of accumulation, and it may now be said, in every sense of the term, that the trade has been secured, with an increase of about 49 per cent. upon the returns received from pre-war German trading, and this by a simple process, involving no material encroachment upon the yard space or additions to the working staff, and at a comparatively nominal capital outlay.

BRITISH INDUSTRIES FAIR, 1917.—Manufacturers who are exhibiting at the British Industries Fair have received their allotments of space from the Board of Trade during the last few days, and the work of erecting stands has already begun. The total amount of space applied for has again largely exceeded the space at the Board's disposal, with the result that exhibitors have found their allotments considerably reduced. In some cases it has even been found necessary to reduce the applications by half. This reduction in size of the stands is, however, a matter for congratulation, as it tends to make the fair more compact without in any way detracting from its commercial utility. Last year's fair was held in the Victoria and Albert Museum, a portion of which had kindly been placed at the disposal of the Board of Trade by the Board of Education. As this year the Board of Trade have been able to secure not only a portion of the Victoria and Albert Museum, but also the great hall and certain galleries in the Imperial Institute, which have been kindly lent by the Executive Council of the Institute and the University of London, the space covered by the fair will be considerably larger than last year, and the number of exhibitors will also be greater. The fair will open on the last Monday in February (February 26) and will remain open till March 9. The London Fair, like all such undertakings, comes under the restrictions imposed by the Ministry of Munitions, and consequently certain trades, which would otherwise be included, cannot participate. The trades which will exhibit are: toys and games; earthenware and china; glass; fancy goods; stationery and printing. The Glasgow British Industries Fair, which is under the auspices of the Board of Trade, and has its full support, will include: textiles; ready-made clothing; boots and shoes; foodstuffs (prepared and preserved); domestic chemicals. By this new system of holding more than one fair at the same time, while carefully preventing the duplication of the participating trades, the inducement to foreign buyers to visit the country is greatly increased. A supply of invitation cards and printed notices drawn up in the language of the country for which they are intended is sent to H.M. Consuls and Trade Commissioners all over the world, all of whom are requested to make the fairs known in their respective districts.

INDUSTRIAL NOTES.

THE War Cabinet has instructed the Secretary of State for War to call up for military service all lads as and when they attain the age of 18 years, instead of, as at present, 18 years and 7 months.

The only lads as a class who should not report are those who have passed through an apprenticeship in one or other of the skilled engineering trades, and who are fully engaged on war work in the shipyards or munitions factory. Such lads should remain at their work.

The President of the Board of Trade has appointed Mr. Adam Nimmo to be chairman of the committee appointed to consider the position of the coal trade after the war, especially with reference to foreign competition. Mr. Nimmo takes the place of Lord Rhondda, who resigned in consequence of his acceptance of office as President of the Local Government Board.

Mr. F. Kellaway, M.P., Parliamentary Secretary to the Minister of Munitions, stated last week that there are at present in national factories and controlled establishments close on 500,000 women working day and night, who are as really protecting the sanctity of their homes and the national honour as are the men who, with incomparable bravery, storm the German positions. Much greater effort is needed unless we are to lose the advantage secured to our armies by the work done under the direction of Mr. Lloyd George and Dr. Addison at the Ministry of Munitions. Germany is making a new and gigantic effort to overtake us in this war of material. She is bringing back from the colours great numbers of skilled men. Her levy *en masse* is placing at her disposal an immense supply of additional labour. We shall be making one of the greatest mistakes of the war, added Mr. Kellaway, if we do not realise the grave significance of the fact that Germany is striving to increase beyond anything yet imagined the material at her disposal when the time for a sustained and extended offensive returns. Germany, to a great extent, is relying upon forced labour. Our women have come forward voluntarily, and will come forward in greater numbers as soon as they realise the national need. If we succeed, as we shall succeed, in overwhelming the mass of material which Germany will have prepared, it will be because the women in this kingdom have shown themselves willing to work for the cause for which their men are prepared to die.

The selling price of aluminium ingots of ordinary commercial purity of 98 to 99 per cent. has been fixed by the Ministry of Munitions at 225*l.* per ton, carriage paid to consumers' works. The maximum selling price of remelted aluminium scrap and swarf ingots of 98 to 99 per cent. purity has been fixed at 210*l.* per ton, carriage paid to consumers' works. The maximum price must not be exceeded, but a lower one may be fixed by agreement between the seller and the buyer, based upon the metallic aluminium content. These prices take effect as from the 1st inst., and permits under Regulation 30A of the Defence of the Realm Regulations will be granted only for such dealings in the above-mentioned materials as are in accordance with the above prices. The said prices are subject to alteration at any time, as may be directed by the Minister of Munitions.

The Ministry of Munitions learns that, with regard to the instruction contained in the Circular Letter (M.M. 100) giving notice of withdrawal of war-service badges and certificates from all semi-skilled and unskilled men, many firms have not yet complied with the requirements in paragraph 3 thereof, viz.: "... under Section 11 of the Munitions of War Act, 1915, to make a return in triplicate of all men in your employ, and shown on your register M.M. 37/B or D.R. 17, as the case may be, on the first day of December, 1916, as unskilled of 30 and upwards (on Form No. 82/K), or semi-skilled of all ages (on Form No. M.M. 82/H). The copies of such return must be addressed to the Divisional Officer, Board of Trade, of your district. . . ."

The Ministry of Munitions accordingly desires to give warning that any firms which have not yet made full returns on Forms M.M. 82/H and M.M. 82/K to the Divisional Officer of the district in which their works are situate, and do not immediately comply with the instruction in question, will be considered by the Department to have failed to comply with a requirement of the Minister of Munitions, and will expose themselves to prosecution in the terms of Section 11 of the Munitions of War Act, 1915.

We read in *Engineering News*, New York, that the Alpha Portland Cement Company began shutting down its cement kilns every Sunday in June last; it has continued the practice ever since. It tried shutting down the kilns empty and loaded, and found it preferable to shut them down with the load in them. Though the wages per week are lower, since the wages paid are for six days' work instead of for seven the workmen are satisfied with the change.

Representatives of the railroads and railroad brotherhoods have been conferring informally in New York, says the *Railway Review*, Chicago, in an effort to reach an adjustment of the eight-hour controversy independently of the Adamson law, the operation of which is suspended until the Supreme Court passes it. Mr. W. G. Lee, president of the Brotherhood of Railway Trainmen, has stated that if the negotiations come to a successful end the disputes between the railroads and the employees will be taken out of politics by the establishment of some kind of a Federal Commission to take the place of the present Board of Mediation and Conciliation. He said that the members of this Board should be practical men from both sides, appointed by Government, and answerable to the President, with full authority to hear and dispose of all controversies that arise. He added that a Board composed of four brotherhood men and four railroad representatives, cut loose from the organisation, and from their railroad interests, would form a Commission to the fairness of which he would be willing to subscribe. In his opinion, "with such a Commission, 90 per cent. of all so-called grievances that originate would be settled satisfactorily."

We read in the *Iron Trade Review*, Cleveland, Ohio, that women are beginning to be serious rivals for men's jobs. Following the walkout of Dayton machinists in August, manufacturers began employing women. They proved so efficient in their new line of endeavour that factory heads will keep the strike-breakers at work. The Recording and Computing Scales Company is one of the large concerns to employ women on the hand presses. Men still do the lifting, but the women are actually doing the delicate work in the Dayton factory, and the manufacturing concerns are opening their plants more and more to woman labour. "Women are better fitted for delicate work," is the explanation given for supplanting man labour with woman labour. "They are much more industrious and seldom shirk. The only drawback is that women know little of machinery. This difficulty will be met in time."

The Midvale Steel and Ordnance Company, says the *Iron Age*, offered, on the 3rd inst., to officers and employees, an opportunity to subscribe for 6,000 shares of its stock. A subscription price of 60 dols. per share (par value 50 dols.) was made, and the following table shows the maximum number of shares which may be subscribed for by the individual:—

Employees Receiving Annual Salaries or Wages of		May Subscribe for a Maximum Number of
600 dols. or less	....	2 shares.
600.01 to 1,200 dols.	....	3 ,,
1,200.01 to 1,800 ,,	....	4 ,,
1,800.01 to 2,500 ,,	....	5 ,,
2,500.01 to 3,300 ,,	....	6 ,,
3,300.01 to 4,200 ,,	....	7 ,,

Employees receiving salaries in excess of 4,200 dols. per annum will be entitled to subscribe for 7 shares, and, in addition, 1 share for each 1,200 dols. of the excess of their respective salaries above 4,200 dols. Not more than 20 shares will be allotted to one subscriber. Payment of subscriptions may be in monthly instalments, to be deducted from the salary or wages of the subscriber. No instalment may be less than 2 dols. per share, and must not exceed one-fourth of any month's salary or wage. Payment for the stock must be completed within three years, *i.e.*, not later than December 31, 1919; interest at 5 per cent. will be charged on deferred payments. Dividends or special allowances will be credited to the account of the subscriber as part of his payments.

Mr. E. Manville delivered his presidential address to the Coventry Chamber of Commerce on the 18th inst., and stated that the British working classes had, during the war, shown a most commendable spirit in producing the greatest possible output. With not far short of 5,000,000 men called to the Government service in one form or another, the volume of trade was absolutely larger than in 1913. The resources of this country in machinery had been enormously increased by the expenditure of the nation during the war, and if the labour of the country, efficient as it had proved to be, would make use of the machinery now in existence by producing with it the maximum possible output, it was certain that no other part of the world would be able to excel this country in the cheapness and excellence of its products. The Federation of British Industries had been unremitting in its efforts to bring into closer contact employers and workpeople, and those acquainted with the progress made felt the greatest satisfaction at the results so far achieved. Both sides were finding that on all the main points capital and labour could join hands and see that what was to the profit of the one was to the good of the other. Labour could never go back to the pre-war standards of pay, and capital could well afford better rates of pay, a greater share in the profits made, if labour would do its part towards unrestricted output. That, he thought, was going to be the essence of the outcome of the conferences being at present held, and that would be the opening of a new era in the industries of this country which promised the most satisfactory results. It might be fairly said that unlimited Free Trade was now looked upon by all parties as a system of the past, and the question of the extent to which Protection should be afforded to those industries requiring it in the period immediately after the war would be considered on non-party lines and determined by the exigencies of the case as they presented themselves. By its intelligent use we should be able to make a commercial alliance with our Dominions and Allies, and this should enable us to put up a front against our present enemies which would be thoroughly effective. After 30 months of an unprecedented and almost unthinkable war we were still in a financially sound position, with our resources not very seriously infringed on. The end of the war, when it came, sooner or later, even with the imposition of greater taxes, would leave us with a heavy liability to face, and it was evident the major part of its cost would be borne by the present generation. It would, therefore, be imperative for all to work harder and more efficiently than before, not only to increase our production of national wealth, but to maintain the supremacy of the kingdom.

Speaking at Rotherham last Sunday, Mr. John Hodge, the Minister for Labour, stated that for a great many years Labour had been asking for a Labour Ministry, but now he regretted to say that in one instance he had been turned down by his own Labour people. He had been asking for Labour men on a Government Committee. He invited one of the federations of trade unions to nominate for a committee, and they had refused. That was not playing the game; he trusted they would realise their blunder and reconsider their position. He had been studying the problems which would arise after the war in regard to demobilisation. There was no doubt that workmen by themselves could not place "the lads" in employment when they came back without trouble and friction, but if they could get the wholehearted co-operation of employers and workers, the task would be a comparatively easy one. He meant, he added, to have the machinery ready for that. He had also mapped out a policy which would more than double the number of Exchanges. Previous to the war, Mr. Hodge also said, he thought Free Trade meant the prevention of hostilities, but he was going to have no more German steel imports whilst there was an idle furnace in this country. So-called Tariff Reform did not mean the lowering of the standard of life.

The Clyde District Committee of the Amalgamated Society of Engineers have applied to the Employers' Federation for an advance of 4*d.* per hour.

The sixteenth annual conference of the Labour Party opened on Tuesday at the Albert Hall, Manchester, when Mr. G. J. Wardle delivered his presidential address. The proceedings on Tuesday were mainly of a political nature. At their close a vote was taken on the Executive Committee's report in regard to the inclusion of members of the Labour Party in the Government, when there voted in support of the participation of Labour in the Ministry 1,840,000, and against 307,000, or a majority of 1,533,000 in favour. In the course of Wednesday's proceedings resolutions were passed dealing with the reorganisation of work after the war and with the reorganisation of Labour Exchanges. In the course of a speech on these subjects, Mr. John Hodge, the Minister for Labour, assured the conference that every promise that Government had made would receive legislative effect. His desire was to utilise trade union machinery to the utmost of its power in replacing not only the demobilised soldiers, but in doing the best that could be done for the demobilised munition workers.

NICHROME CASTINGS FOR HIGH TEMPERATURES.—Castings of nichrome intended to withstand temperatures of from 1,000 deg. F. up, without corroding, are covered by the U.S. patent, No. 1,190,652, granted to John C. Hewerson, Washington, D.C., and assigned to the Driver-Harris Wire Co., Harrison, N.J., says the *Iron Age*. The composition is 60 per cent. of nickel, 26 per cent. of iron, 12 per cent. of chromium, and 1.5 per cent. of manganese. If comparatively carbon-free—under 0.40 per cent.—the alloy can be machined, rolled or forged. The alloy requires a high melting heat, but can be cast in the ordinary manner. It is said to be suitable for valves and valve seats of internal combustion engines, among many other uses. The manganese content is not essential. A slight film of oxide forms on the surface of the article under oxidising conditions, which is said to be strong and durable, and resistant to sulphuric and other acids; the film adheres strongly.

THE MANUFACTURE OF GAUGES.

*The Manufacture of Gauges at the L.C.C. Paddington Technical Institute.**

By A. G. COOKE, M.A., W. J. GOW, A.R.C.S., and W. G. TUNNICLIFFE, Associate Member.

ALTHOUGH the authors make no affectation of secrecy with regard to the ultimate purpose of the work described in this paper, it will be wise to avoid, not only matters of organisation and finance, but even reference to any other agency concerned, whether authoritative or auxiliary. Nor do they pose as scientific experts, after 18 months of auxiliary labour, on a matter that requires a lifetime of study. In the standardisation of an engineering industry vastly exceeding in magnitude any previous human experience, they have been honoured with an important share in practical constructive work, not on account of any recognised merit or skill, but the accident of being the largest technical institute maintained by the largest education authority.

The authors deal with workshop details and methods of securing a high degree of mechanical accuracy under conditions of great urgency and without special equipment. As this work would differ in no particular from that required in the standardisation of any engineering industry of great magnitude, they may hope that an account of their experience may not be without value when another great national effort is required to restock the world with the munitions of civilisation.

This is an Institute devoted to the technical education of the artisan and foreman. The workshop staff is exclusively composed of teachers engaged in the early training of this class, and the pupil assistants are boys representative of the intermediate training. A severe practical test of their efficiency has been made, and their claim is that they have justified the confidence of engineers, even though they may have contributed little that is novel to the science of workshop accuracy.

At the close of the session for evening classes in 1915 the *personnel* of the mechanical engineering department of the L.C.C. Paddington Technical Institute was reduced to the head, who, with the principal, was continuing the engineering teaching of a junior technical school of 100 boys (14 to 16). Of the five permanent teachers of engineering, four had joined the army and the fifth was "on loan" to a munition factory. From the elementary schools of the council were transferred two metal-work instructors who had experience in gauge-making, Mr. W. G. Tunnicliffe and Mr. H. C. Christie. Under their immediate direction were placed five other metal-work instructors and 16 selected woodwork instructors.

Boys of the junior technical school in their second year were also employed; the ultimate arrangement adopted being for classes of about 17 to work every third week for 44 hours. Experience confirms that this is excellent in results, and worthy of consideration as a permanent system of engineering training.

Machinery that had been in ceaseless use by day and evening students for ten to a dozen years could hardly be expected to be ready for work of the highest accuracy. But no other was available. Practically for all but the "roughing-out" machines complete reconstruction of those essential lathe parts on which precision depends was the first operation.

Nature of Manufacture.—An explanation is necessary as to the nature of the work undertaken, and its place in relation to the whole industry. The precision desired for primary standards for laboratory testing is limited by practical possibilities only, and the manufacture is not a "commercial proposition." Inspection gauges, or secondary standards, are to be manufactured within a determined though small range of variation or "tolerance." This tolerance should be regarded as a definition, not an error limit. Within the tolerance all values are "correct." In consequence, the manufacture is entirely a question of competitive cost and urgency of delivery.

That standardisation is the key to efficient manufacture and a large output is universally recognised. It is not so well understood that simply on account of the magnitude of the output, apart from the question of excellency of workmanship required, the necessity for standards of a higher order of accuracy arises. It is easy in a small workshop to insure by trial that all fitting is satisfactory; in fact the initial magnitudes are generally determined by the same tools and standards. In a larger workshop the work is linked by more accurate gauges; and it generally matters little if the abso ute measurements vary appreciably from those specified in the design. But when an industry grows to a national or international extent, the standards must aim at specified dimensions of absolute magnitude, defining exactly the limits of permissible variation on either side of the standard, so as to include all acceptable and reject all unacceptable variations from the correct value. In the language of the calculus, in order to limit variations to a defined "small quantity" inspection gauges are required to be true to the "second order of small quantities." It is just in so far as we can rely on the accuracy of inspection gauges to define the limits of variation permissible that the designer can allow those limits to be extended with safety. Hence the apparent paradox that high accuracy in the inspection gauges allows more laxity, and so increases facility and speed of manufacture.

Limit Gauges.—There is no need to describe in detail the principles of limit gauges for measurements of length and diameters. Both workshop and inspection gauges were manufactured, the essential difference being that the former must be adjusted to be within the specified limits, while any tolerance permissible in the latter must be outside, so as to pass all acceptable work. Tolerance in a workshop gauge tends only to increase the margin of safety, enforcing greater care in manufacture than necessity demands. Uncertainty and variation in inspection gauges is not only unjust to one manufacturer, but affects all by necessitating closer limits.

The necessary order of accuracy for this type of gauge—three ten-thousandths is generally specified—can be obtained with universal grinders. As the demand was urgent, and grinding machinery not available, the authors had to resort to handwork. Lapping with high-speed motors up to 3,000 or 4,000 revolutions, and other devices for acceleration were developed.

Position Gauges.—The greater part of the work entrusted to this institute consisted of a class of gauges determining position or some geometrical feature, involving greater difficulties in theory and practice than a single directly measured dimension. Concentricity, perpendicularity, or parallelism, and distance between centres of turning and drilling, are examples. The authors are unfortunately unable to give details, but it will be seen that to determine some such geometrical condition, or primary measurements, in the work to be tested, limits of accuracy are allowed by a definite variation in the size of diameters of cylinders, pins or drillings, so as to allow slackness. The gauge limits the combined errors in jig or automatic tool work.

It will be seen that any variation of the inspection gauge, as regards the primary condition, simply displaces the limits which it is intended to give, rejecting satisfactory and accepting unsatisfactory work through a range of double its own error. The practice is to allow a gauge tolerance of only 0.0001 in the primary measurement, and a combined tolerance of 0.0003.

Screw Gauges.—The methods by whch the authors attained the high accuracy required for screw gauges are selected for description. They try to limit any discussion of scientific principles to such as directly affect their work in the construction of the gauges. In screw gauges the gauging surface is an elaborate skew surface, all parts of which are required to be within the limits, in general fixed at three ten-thousandths measured radially from the axis (0.0006 in diameter). This means only about 1½ ten-thousandths normally to the slope of the threads. It must not be forgotten that this is the second order of small quantities necessary to define a larger variation permissible in the work. As a variation of which this is 5 per cent. would allow a sheet of *The Times* newspaper to be used as packing (three thousandths), it cannot be regarded as too fine.

It should be evident that the accuracy in pitch of the lathe used should be such that no divergency from the correct value greater than about 1½ ten-thousandths should exist throughout the range used. For this would cause a skew surface otherwise cut in correct shape to the mean value to pass outside the limits allowed. If any further error in pitch exists, up to an extreme value of three ten-thousandths, it is only possible to keep within limits by thinning of threads, reducing the effective diameter, and the practical difficulties of the reduced margin increase rapidly if the above error is exceeded. The authors found that the lathes by a number of manufacturers showed an error in pitch of about 2 in 1,000

Fig. 1. APPARATUS FOR PITCH MEASUREMENT.

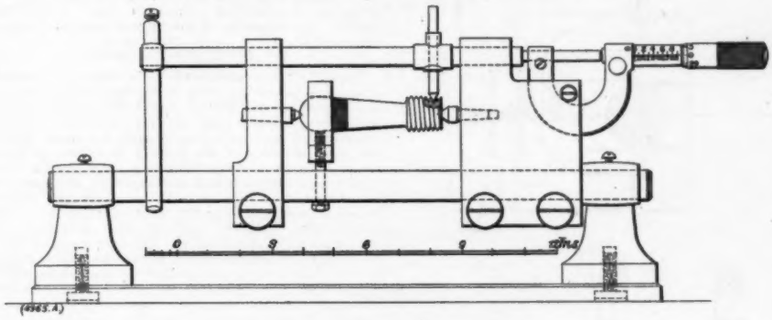


Fig. 2. TESTS TAKEN ON OPPOSITE SIDES OF A TEST-PIECE OF 14 THREADS TO THE INCH, LEADING SCREW-PITCH 4 THREADS TO THE INCH.

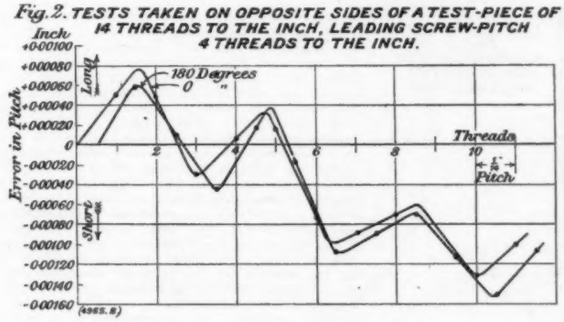
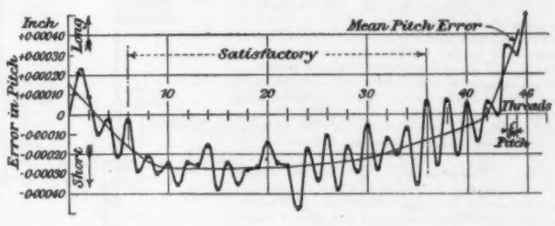


Fig. 3. FINAL TEST ON A SCREW SHOWING A SATISFACTORY RANGE FOR A LENGTH OF 1¼ INCHES.



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* Paper read before the Institution of Mechanical Engineers, Friday, January 19, 1917.

each groove, and those calculated for a correct view of the presumed pitch, are plotted as ordinates in Figs. 2 and 3 (page 89). These are selected from a large store of records as the first and final pitch diagrams of test-pieces from the same lathe before and after correction. The test of Fig. 3 was taken on opposite sides of a test-piece of 14 threads to the inch, the leading screw-pitch being presumed 4 threads to the inch. Analysed, it shows a fairly uniform progressive error of 0.0022 per inch, with superimposed periodic errors corresponding to the revolution of the leading screw, of amplitude 0.0004 in. The lathe was in good condition, fairly typical of ordinary workshop accuracy.

Two methods of correction for progressive error were considered:—

(*a*) By accelerating the motion of the top slide of the compound rest by means of a weighted lever attached to the screw. The screw of the slide was turned at a uniform rate as the saddle traversed along the bed of the lathe, by making the end of the lever move down an inclined plane, the slope of which could be readily determined from the known pitch error.

(*b*) By selecting a new train of wheels, a process demanding some considerable calculation by trial and error for different pitches, but which has proved quite possible in all cases. For example, the train of wheels, drivers 38 and 20, followers 91 and 50, gives a pitch of 24 to the inch correct to less than 0.000007.

The periodic errors corresponding to the revolution of the leading screw may be due to:—

(1) Reproduction of an error in the leading screw.

(2) An axial movement of the leading screw with each rotation, owing to both the thrust collar and bearing being out of truth.

(3) Lack of straightness or stiffness in the leading screw, causing oscillations at the point of contact of the nut.

To correct (2) the collar bearing on the leading screw was dispensed with, and the thrust was carried by a single ball bearing applied to an enlarged centre on the leading screw. The collar was turned off and the screw made to run free in its bearing. A ½-in. ball was used, and the thrust taken by a bolt screwed through a bracket and locked in position, the end of the bolt being made intensely hard.

After testing and correcting the change-wheels for eccentricity, it became evident that a more accurate and rigid leading screw was necessary. A new leading screw was cut on the milling machine on a sleeve of 2 in. diameter and 8 in. in length, with a pitch intended to be 12 threads to the inch. A split nut, 2½ in. in length, was clamped by a weighted lever. Mounted on the original leading screw as shaft a progressive error of 0.0008 was found, with a periodic error amplitude nearly 0.0003. On substituting a short stiff shaft the latter was reduced to an amount not exceeding 0.0002, which may be considered satisfactory. The progressive error was approximately corrected by the following gear wheels:—

For 24 threads to the inch	45 × 30 drivers. 38 × 71 followers.
For 14 threads to the inch	36 × 67 drivers. 74 × 38 followers.

The final test, showing a satisfactory range for a length of 1¾ in., is shown in Fig. 3. This length, carefully marked, was sufficient for the gauges required.

The apparatus for effective diameter measurement is shown in Fig. 4. The micrometer carriage, mounted on balls, is constrained to move in a plane at right angles to the axis of the screw to be tested. This apparatus may also be used for measuring core diameter, by using triangular prisms in place of the small cylinders.

An ordinary 0 to 2 in. micrometer, fitted with a special adjustable attachment to enable direct measurements to be made of core diameter, is shown in Fig. 5 (annexed).

Optical Projection.—Enlargement by optical projection was first resorted to for adjustment of the shape of tools for screw cutting, and verification of the shape of thread. Finding the possibilities for accuracy of measurement were greater than was thought possible, and well within the tolerance allowed, the use was extended to a large variety of gauges, particularly to plate gauges of shape, slots and holes, curvature and cone angles, &c.

The key to the method is to secure, as nearly as possible, a truly parallel beam of intense light, freed from heat rays by passage through a saturated solution of alum. An optical bench of great rigidity, and sensitive and universal adjustments, carries the gauge or tool and projecting lenses. The screen is at a distance of about 16 ft.

The necessity of a parallel beam (except for tool edges) should be obvious in dealing with gauging surfaces such as plates and screw-threads, and adjustment for tangential or grazing incidence must be as fine as possible. This limits the field for simultaneous survey to that of the area of the projecting lens. A combination of three optical elements was designed to give variable magnification up to 400. About 180 is, however, ample, and visible in undarkened room. Where it was desired, as in a few cases, to cover a larger gauge length than about ½ in., a triple achromatic lens of 2-in. diameter and 6-in. focus was combined with an astigmatic lens. The area surveyed on this extended up to over 1½ in., with 50 magnifications on a 6-ft. screen. Quick interchange of gauges and tools from optical bench to vice or lapping motor with the minimum of readjustment is essential.

Fig. 4. APPARATUS FOR EFFECTIVE DIAMETER MEASUREMENT.

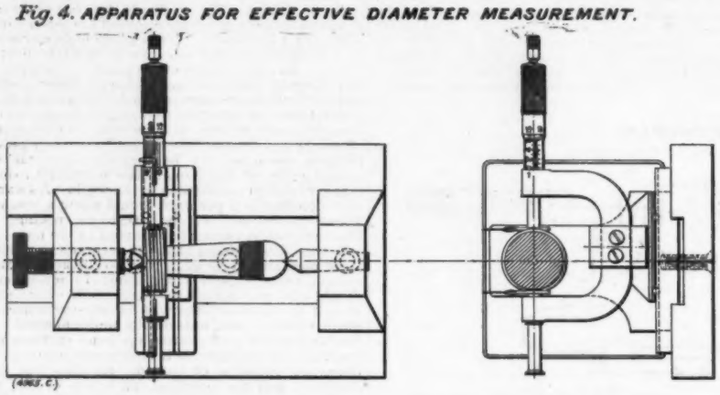
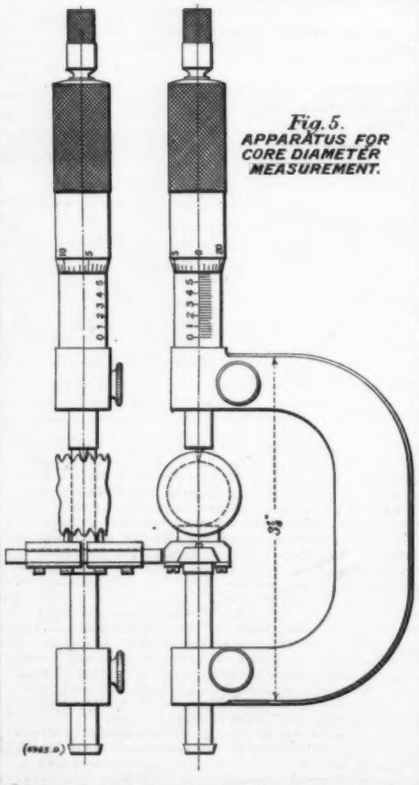


Fig. 5. APPARATUS FOR CORE DIAMETER MEASUREMENT.



Shaping of Screw-Threads.—With a magnification of 166 a clear definition of the working edge of the single-pointed tool for screw cutting is possible to much less than a ten-thousandth, this being represented by one-sixtieth on the screen. The angle and rounding off of the nose for the required pitch are adjusted with a fine oilstone to this degree of accuracy, after hardening without tempering, and quickly readjusted after wear. The same tool is used to cut the groove in a capping tool for the crests. It is then possible to insure correct shape, provided that the relation of core to effective diameter is checked by measurement.

In the final projection of the screw-thread in silhouette a careful examination for symmetry is advisable, checking the setting of the tool. A small margin in all dimensions is left for lapping, which removes some residual errors, the margin being increased if a hardened gauge is required. For rapid lapping the screw gauge is held in a self-centring chuck on the shaft of a 1-h.p. electric motor. This is automatically controlled by a reversing switch, so that it rotates with precision, uniform torque, and any desired speed, two revolutions forward and backward.

The laps are made of cast-iron, cut with a tap, or on lathe, split, and adjustable for wear. Frequent re-tapping retains the shape. For the core a lap is prepared with a slightly thin thread, and for effective diameter a full thread with crest removed.

INDUSTRIAL AND SCIENTIFIC RESEARCH IN CANADA.—The Imperial Trade Correspondent at Toronto, says *The Board of Trade Journal*, has forwarded an extract from the local press, dated December 1, from which it appears that the Dominion Government has appointed an Honorary Advisory Council on Industrial and Scientific Research. This Council will work with a Government sub-committee consisting of the Ministers of Trade and Commerce, Interior, Mines, Inland Revenue, Labour and Agriculture. Among the questions to be considered are the utilisation of waste products; the discovery of new processes—mechanical, chemical and metallurgical; and the development of the unused natural resources of the country.

AMERICAN SHIPBUILDING.—We read in *International Marine Engineering*, New York, that while the annual meeting of the Society of Naval Architects and Marine Engineers, recently held in that city, was not as well attended as was earnestly desired by those who have the best interests of the society at heart, nevertheless the society gave every indication of a healthy growth, both in membership and in interest in the work before it. Throughout the proceedings there was evident a most optimistic feeling for the future of the American shipbuilding industry and for the upholding of the American merchant marine. The conditions in the shipbuilding field throughout the world which have developed in the last two years, adds our contemporary, give promise of a long-continued period of prosperity for American shipbuilders and a most hopeful situation as regards the growth of the American merchant marine.

PROPOSED FREE HARBOURS IN SWEDEN.—It is stated that Malmö, Gothenburg and Stockholm are to have free harbours. In 1915 a detailed plan to this effect was prepared by the Stockholm harbour construction office, but the harbour board delayed the carrying out of the scheme, intimating that the time had not yet arrived for such a large undertaking. The Stockholm municipality, however, took a different view of the matter and appointed a special commission to deal with it. This commission prepared a new detailed plan, and urged the prompt execution of the work. The commission point out in their report that the beneficial effects of free ports have been demonstrated in Copenhagen. Stockholm's commercial intercourse with Finland and Russia, and with distant countries such as China and Japan, has increased to a marked extent during the last few years. The report recommends that work on the Stockholm free harbour should be commenced in the course of 1917 and completed within five years. It is proposed to leave the working of the new port to a limited company; the construction is to be carried out by the municipality. The cost is calculated at 20,460,000 kronor, of which 15,900,000 kronor would be for the free harbour proper and 4,560,000 kronor for warehouses, &c.

INDIAN RAILWAY ADMINISTRATION.—The capital expenditure made by the Bengal and Nagpur Railway Company in the year ended March, 1916, was mainly on rolling-stock ordered before the war and improvements to the main line and to the company's workshops at Kharfur. There was also an expenditure on the Bokharo colliery and on the Tumsar Road–Tirodi tramway. No new construction was in progress during the year. The rolling-stock at the close of March, 1916, included 500 locomotives, 950 coaches, 14,504 goods trucks, and 803 miscellaneous vehicles of 5 ft. 6 in. gauge; and 106 locomotives, 275 coaches, 1,405 goods trucks, and 113 miscellaneous vehicles of 2 ft. 6 in. gauge. During 1915–16 the rolling-stock was increased by 34 locomotives—32 coaching and 693 goods engines—of 5ft. 6 in. gauge, and by 20 locomotives—7 coaching and 147 goods vehicles—of 2 ft. 6 in. gauge. In addition to this new stock, 12 locomotives—67 coaching and 274 goods vehicles—of 5 ft. 6 in. gauge, and 10 locomotives—65 coaching and 9 goods vehicles—of 2 ft. 6 in. gauge, were in course of supply or erection; all this new stock was ordered before the war. The company's present floating stock includes 4 ferry steamers, 4 steam launches, 5 barges, and 4 ferry pontoons. The total mean mileage worked in 1915–16 was 2,688½ miles, viz., 5 ft. 6 in. gauge, 1,894 miles; 2 ft. 6 in. gauge, 794½ miles. There was an increase of 357,162 tons, or 5½ per cent., in the weight of goods carried in 1915–16. The largest increase occurred in coal, and was due to increased long-distance coal traffic via Nagpur, Walthair and Kutni. There were also substantial increases in cotton goods, due to heavy bookings to Calcutta. There was an increase in the working expenses last year, principally attributable to higher expenditure in connection with maintenance of way and works and locomotive charges. The increase in the maintenance of way and works was chiefly explained by some relaying and re-sleepering having been done. The expenditure on strengthening bridges and repairs to damages caused by cyclones and floods was smaller.

WORM GEAR AND WORM GEAR MOUNTING.*

By F. W. LANCHESTER, M.Inst.C.E.

(*Continued from page* 67.)

THE experience of the Daimler Company, though dating from more recent time, is considerably wider than that of the Lanchester firm, inasmuch as the range of sizes and standards, as defined by the different centres and ratios of gear, is far greater; the applications range from the lighter types of pleasure vehicles, both petrol and electric, to the heaviest type of motor lorry, namely, the five-ton vehicle.

The whole range of the Daimler-Lanchester worm gear standards is laid out diagrammatically to scale in Fig. 21.† The different standards of blank are designated by the capital letters A, B, C, &c., in the order in which they were initially established. Types A, B, C, F, and K have been produced for private pleasure cars, &c., types D and L more particularly for electrical vehicles (supplied mainly to the U.S.A.), types H, J, and O for commercial heavy vehicles, and type G for particular application to (stationary) power transmission.

Thus, in greater detail, type B, 6-in. or 152-mm. centres, is that used almost universally in full weight touring cars, limousines, &c.* Type K, 137-mm. or $5\frac{7}{16}$-in. centres, for cars of, say, 20 "legal"† h.p., weight not exceeding 32 cwt. gross. Type F, 120-mm. or $4\frac{3}{4}$-in. centres, for cars of, say, 16 "legal" h.p., not exceeding 28 cwt. gross.

The types H and J, $7\frac{1}{2}$-in., or 190-mm. centres, are for 3-ton lorries, bus chassis and the like. Type O, 9 in. or 228-mm. centres, is for the heaviest road vehicle at present in ordinary commercial use, namely, the 5-ton lorry.

A typical mounting for the A and B standards of gear is illustrated in Figs. 22 and 23. There is little to be noted here except the self-adjusting spherical thrust bearings, which prevent undue or unevenly distributed stresses on the thrust bearings as plausibly due to any slight "whip" or spring of the mounting or want of alignment. Contrary to the Lanchester Company's practice, also, it may be noted that the road-wheel thrusts are taken independently of the differential box mounting.

Figs. 24 and 25 illustrate the mounting adopted in the 20-h.p. Daimler chassis, used to a considerable extent for Staff, Red Cross and other purposes at the Front. In this mounting the worm is on top, and the worm box is cast integral with the main portion of the gear-box. An interesting feature in this mounting is the fact that the thrust is placed adjacent to the worm itself, and the bearing is placed beyond. This inversion of the usual order results in a bigger bending moment on the worm shaft, but there is ample strength to carry this. The advantage lies in the fact that as designed there are, including the worm, only five parts in the mechanical circuit, if we regard the variation in ball diameter as negligible. These are the worm, the thrust half-bush, the thrust live ring, the thrust fixed ring, and, finally, the gear-box casting. Thus the total variation in the location of the worm is the sum of five tolerances, or, as

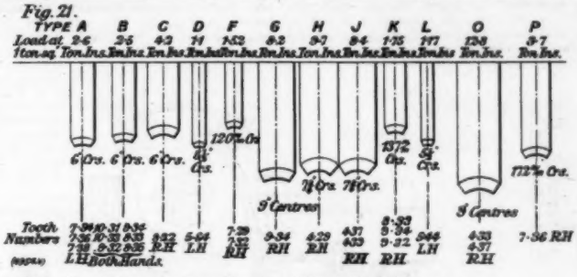


Fig. 21.
TYPE A B C D F G H J K L O P
Load at 1 ton sq. Ton Ins. Ton Ins. Ton Ins. Ton Ins. Ton Ins. Ton Ins. Ton Ins. Ton Ins. Ton Ins. Ton Ins. Ton Ins. Ton Ins.
2·6 2·6 4·2 7·1 15·2 8·2 8·7 8·4 1·75 1·77 12·8 8·7
6 Cts. 6 Cts. 6 Cts. 4½ Cts. 12 Cts. 7½ Cts. 7½ Cts. 5 3/32 Cts. 4½ Cts. 7 1/32 Cts.
9 Centres 9 Centres
Tooth Numbers
7-39 10-31 9-36 7-36 10-30 8-33 8-32 RH 5-64 LH 7-29 RH 9-34 RH 6-29 LH 4-37 4-29 RH 8-32 5-34 9-32 RH 9-44 LH 4-33 4-37 RH 7-56 RH
(4954.) L.H. Both Hands.

FIG. 21. DAIMLER-LANCHESTER WORM-GEAR STANDARDS.

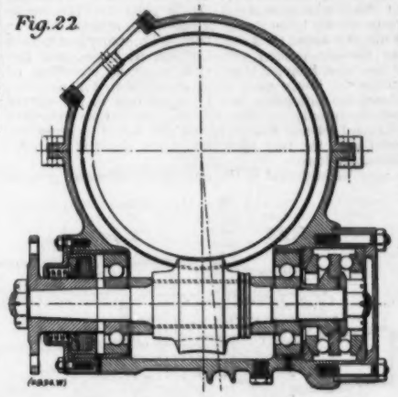
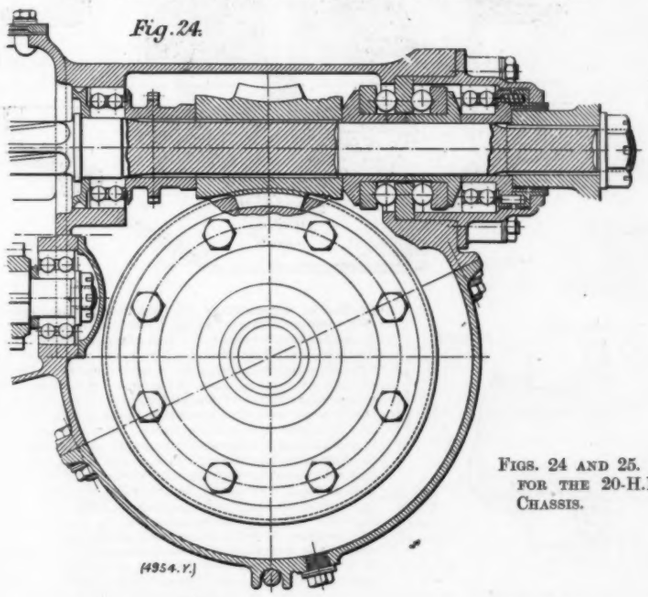
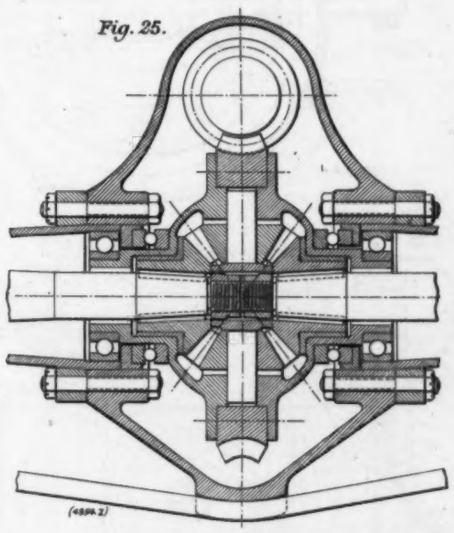
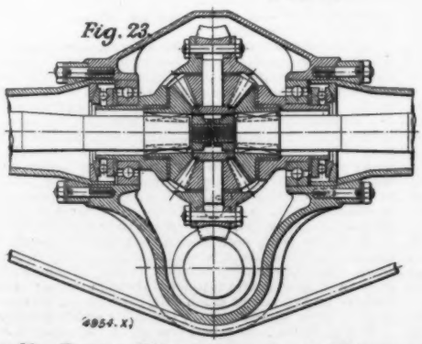


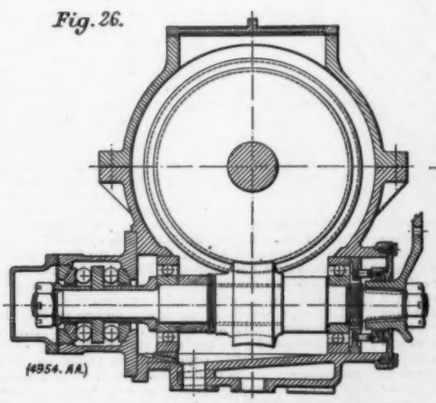
FIG. 22. TYPICAL MOUNTING FOR A AND B STANDARDS OF GEAR.





FIGS. 24 AND 25. MOUNTING FOR THE 20-H.P. DAIMLER CHASSIS.





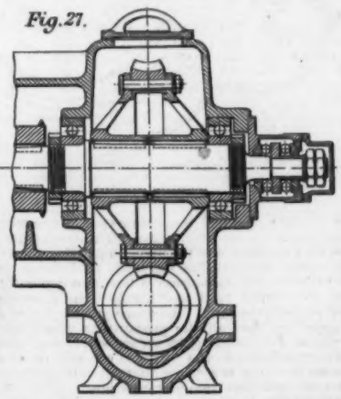


FIG. 23. TYPICAL MOUNTING FOR A AND B STANDARDS OF GEAR. FIGS. 26 AND 27. G STANDARD MOUNTED AS A FIXED TRANSMISSION.

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*Paper read before the Institution of Automobile Engineers on December 13, 1916, slightly abbreviated.

† The Lanchester Company's standards include types A and B only, and are identical with those given, except that the Lanchester Company's list does not include the 9/32 ratio type B, but includes a 6/36 ratio in type A. In addition to this the Lanchester Company's standards in the B type include left-handed cutters only, but their list includes a certain number of right-handed cutters in type A.

* Up to 50 cwt. gross or even over. In all cases it is the weight of the car rather than the horse-power which is of importance.

† The "legal" h.p. is measured by the R.A.C. rating $0.4\ D^2 s$.

already expressed, there are five elements in the mechanical circuit. This may be considered a distinct advance in worm gear mounting as a step to securing interchangeability.

Figs. 26 and 27 show the G standard mounted as a fixed transmission—as such it has been applied for the driving of air compressors, &c., and other slow-running plant from electro-motors. It is good for 150 brake horse-power at 1,000 r.p.m. of the worm shaft.

It may be noted that the Daimler Company's standard types for commercial vehicles (lorries, buses, and the like) are of a heavier type, and, generally speaking, of considerably lower gear ratio than those for pleasure vehicles, the difference being mainly due to the slower speeds commonly in demand and the larger diameter of the road wheels necessary for the duties in question, coupled with the fact that the engine speed is not proportionately lower.

It may be said that in the application of worm gear to commercial vehicles the conditions are on the whole more exacting than in the touring car. The driving mechanism is rarely so refined, and the driver himself is not usually so fastidious. Beyond this, the loads are heavier, the tyres less yielding, the suspension stiffer, and generally all the conditions which tend to "hustle" the gear exist in a more aggravated form. In consequence of this it might be supposed that all the precautions which have been enumerated as tending to secure solidity of the worm-shaft assemblage in the pleasure car will be at least as important in the heavy commercial vehicle: experience has fully justified this anticipation. It is absolutely necessary that the compression parts and thrust surfaces between the various components of the assemblage, namely, worm, spacing collar, roller race, thrust washer, &c., should be of ample area, and on no account must they be left soft. As exemplifying points of good and bad design in this respect a comparison may be made between Figs. 28 and 29. In Fig. 28 a poor design of worm assemblage is illustrated, in which the defects are intentionally exaggerated; in Fig. 29 a good design is given, showing the proportions and precautions necessary to ensure success. Referring to Fig. 28, it will be seen that the thrust surfaces between the spacing pieces at *a*, *b*, *c*, *d*, &c., are of insufficient area. So far as concerns the taking of the necessary thrust reaction, they might with justice be regarded as more than ample; for example, at the point *d* the area of the contact faces is more than a square inch, and may be taken as safe in compression for a force of 10 tons—the actual maximum load is not more than one-third or one-fourth of that amount. As a matter of experience, however, no such design will stand up, the faces in contact are found to undergo punishment, and sooner or later backlash will develop, and the failure of the mounting follows in a very short time. The author has actually seen a case of this kind in which the one part has eaten into the other a matter of 3 or 4 millimetres and the worm has had to adapt itself to an axial displacement of that magnitude; this can hardly be described as fair or proper treatment. When asked how to account for such failures taking place, considering the comparatively light thrust load per square inch carried by the faces in contact, it is fair to say that cases of even admittedly defective design do sometimes stand up; a certain percentage of output will not be reported as giving trouble. The truth probably is that the failure occurs through a little initial "slogger" or backlash creeping in, either from careless mounting, due to insufficient initial pressure being put on by the retaining nut,* or as consequent upon some slight defect in material or by bad or rough handling at some time or another. What has to be remembered is that a mounting which is not open to inspection (without virtually dismounting an axle) must be so designed and constructed as to be reliable even under the most unfavourable conditions; the need for large face contacts and hardened surfaces on which the author is insisting is thus based on experience of what is rather than on calculation as to what might or should be.

A further defect in the design shown in Fig. 28 is the thin distance tube *g* on which the double thrust bearing is mounted; it has been stated that the end nut *h* must be thoroughly tightened in order to secure the assemblage; if, as drawn, too much force were applied, the tubular spacing piece would be liable to be crushed and unknown forces would be brought to bear on the thrust bearing itself, with the imminent risk of its failure—involving the usual undesirable consequences.

On referring to Fig. 29 it will be seen how much greater is the area of the faces provided, and generally what a far more secure job has been made of the worm location. Instead of the worm itself being held on one portion of a shaft and the thrust being held on another portion of the shaft, so that if either of two fixings comes slack the worm develops backlash, we now see the worm and its thrust all held up solid on one section of the worm shaft, so that its location depends upon one fixing in place of two. Also the end face of the worm by which the brake thrust is taken is of increased diameter and bears directly on a face formed on the shaft itself.

In Fig. 29 the system (to which reference has previously been made) of an accommodation piece is employed to overcome the difficulties of interchangeability, the piece in question taking the form of a sleeve on which the double thrust is mounted; the accommodation piece is more precisely formed by the flange of this sleeve, which constitutes a spacing piece between the roller-bearing inner race and the first thrust washer, and its thickness is varied to correct for the combined inaccuracy of the width of the roller race and the thrust bearing dimension. It has been reported that in the particular combination of roller and ball thrust given in Fig. 29 the variation between one sample and another is commonly (on an average) as much as 0.25 mm.* Personally, the author is strongly in favour of dismantling all bearings as they come from the makers and rectifying their important dimensions so as to secure complete interchangeability; however, neither the Lanchester Company nor the Daimler Company has yet taken so drastic a course: the system of the accommodation piece has been taken as the simplest way out of the difficulty. No accommodation piece is wanted to correct for inexactitude on the part of the motor car manufacturer; this is evidenced from the fact that the present procedure is that the bearings are taken to the view room and are "married" in sets, one roller bearing and one ball thrust, and the accommodation piece, the sleeve, is ground to whatever thickness is required in its flanged portion to bring the dimensions accurate between the points *g* and *h*; no similar pairing or grouping of parts is needed in the case of those for which the automobile manufacturer is responsible. It is quite clear from this that the attitude of the bearing manufacturer is quite preposterous, and we may look to his speedy reformation when the number of firms supplying ball and roller bearings have an output in excess of the demand.

Another feature in which the makers of ball and roller bearings have much to learn before the goods in question cease to be a trouble to the designer is that of the radius which it is customary to put on the edges of the bearing races. This is too little, and results over and over again in a designer having to arrange an additional piece in his design in order to adapt the bearing to the shaft on which it is to be mounted. What is far more serious is that in many cases draughtsmen have been led to design shafts with comparatively sharp corners at collared portions in order to suit the bearing. It would be the best course mechanically to pass the bearings through an extra process and appropriately increase the radius to suit the needs of the shaft neck design, but there is always the danger that this might be neglected, especially in garage work, where the bearing is, often enough, obtained direct from the manufacturer instead of through the car builder. This is an evil not so much felt in worm mountings as it is in other applications of the roller or ball bearing.

In Fig. 31 we have a ball bearing as commonly turned out, with its radius of only 3/32 in.; the shaft neck to take this bearing would have to be almost sharp in the corner. The figure shows this bearing accommodated by means of a collar or washer to a properly designed shaft neck. Fig. 32 illustrates what this bearing should be from the point of view of the automobile designer. The author fails to see any reason why a liberal radius, as illustrated, should not be adopted by the manufacturers of bearings. In fully interchangeable work any additional piece in the mechanical circuit, as in Fig. 31, means a fining of the limits of manufacture, with an all-round increase in the cost of production.†

(To be continued.)

Fig. 28.

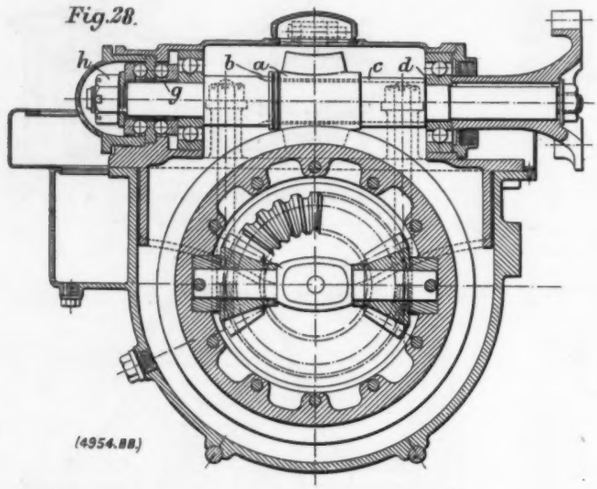


Fig. 30.

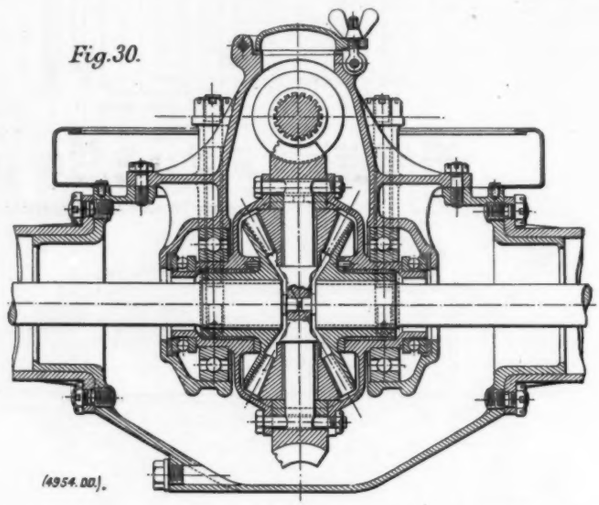


Fig. 29

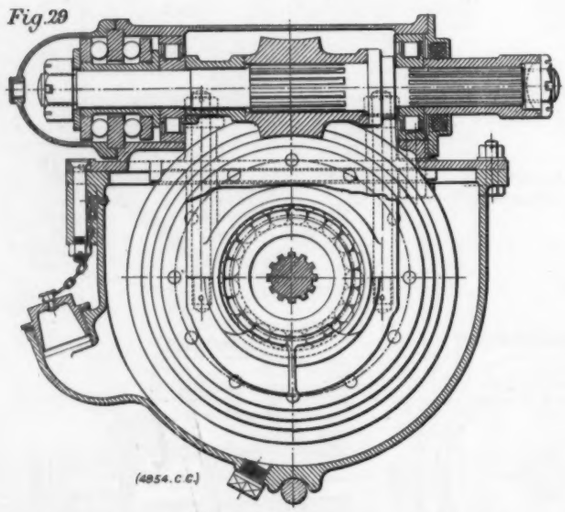


Fig. 31.

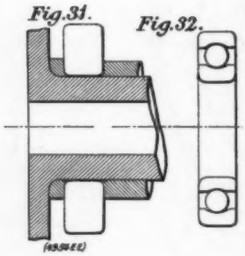


Fig. 32.

* The inclusion of a small quantity of swarf or dirt might be the explanation in some cases.

* In an exceptional case the inaccuracy was no less than one whole millimeter!

† Compare Appendix.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

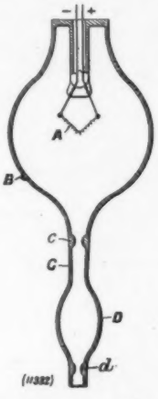
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

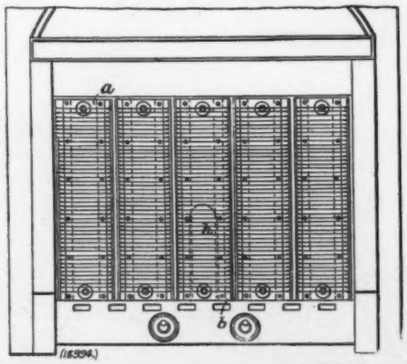
ELECTRICAL APPARATUS.

11,332/15. C. O. Bastian, London. Electric Lamps. (1 *Fig.*) August 5, 1915.—The spiral filament A is mounted in the globe B, and the leading-in wires are sealed in the stem of the lamp; while the globe B at the piecing-tube end of the lamp is temporarily provided with the usual piecing tube C, having a thickened portion *c* forming a contracted passage opening into the temporary pocket D, below which is located the passage having the thickened portion *d*, also forming a contracted passage. In the temporary pocket D or/and within the globe B or/and in the passage C is placed a material, *e.g.*, sodium, for combining with



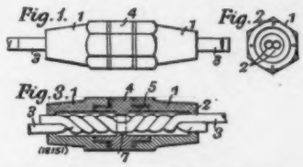
or absorbing any and all oxygen in the globe B. Next, either with or without a preliminary heating of the whole lamp, a seal is formed at the point *d* and then the whole lamp is subjected to sufficient heat, externally applied, to cause the sodium to absorb the free oxygen contained therein. Having thoroughly exhausted the globe B of oxygen and, if desired, having collected any residual matter within the temporary pocket D, another and final seal of the globe B is formed at the point *c* and at same time the pocket D containing said residuals is removed. (*Accepted November* 22, 1916.)

16,994/15. A. F. Berry, Ealing. Electric Radiators. (11 *Figs.*) December 2, 1915.—In an electric heat radiator there is associated with the resistance grid-like structure means whereby air can be caused to act to a different extent upon different parts thereof, for the purpose of correspondingly controlling an effect simulating combustion. A heat radiator comprises a length of resistance material *a* wound backwards and forwards between the notched forward edges of two vertical strips *b* of non-conducting material, so as to form a light vertical openwork grid, the strips *b* being secured to the opposite edge portions of a vertical backing of concave shape in horizontal section, and the space formed between the resistance grid *a* and



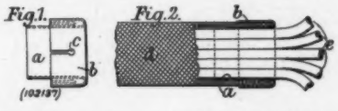
the backing serving as a vertical airway through which air can flow in contact with the rear side of the grid at the same time that air can flow over the front side thereof. For the purpose of varying and controlling what may be called, for brevity, the combustion effect, the electric heat radiator is provided with means whereby the passage of air over and against different parts of the resistance grid can be varied to produce varying effects. Thus there may be arranged behind the resistance grid, or each of them when two or more are used, refractory material *k*, as, for example, sheet mica or quartz, so as to shield part or parts of the rear portion of the grid to a greater extent from the air and also it may be to deflect the air, or some of it, from the said part or parts of the grid, and in this way vary the cooling action thereon of air flowing upward in proximity thereto. By this means the redness of the resistance grid at various parts thereof can be varied, and thus also the amount of heat radiated from various parts of the grid, a greater amount of heat being radiated from the reddest parts of the grid. (*Accepted November* 29, 1916.)

12,151/15. A. H. Fargo, New York, U.S.A. Cable Connectors. (19 *Figs.*) August 23, 1916.—The invention relates to a connector for the adjacent end portions of two wires, the object being to provide a connector which comprises relatively movable sections adapted to partially or wholly inclose said ends, and by the movement of said sections to firmly twist and bind the said ends together in such a manner that a perfect electrical contact, or mechanical co-operation, is maintained. Two similar hollow members 1 are provided having restricted openings 2 in their opposite ends, through which respectively pass the adjacent portions of two conductors 3. Between the first-named members, which are internally threaded in their adjacent ends, is a third member 4, provided with reduced, externally and oppositely threaded end portions 5, co-operating with and securing said members together. The member 4 is provided with



a central transverse wall, provided with an elongated aperature 7, and between the respective inner ends of the members 1 and the central portion of the member 4 are preferably provided water-tight washers. In operating this device the end portions of two wires are passed in opposite directions through the respective apertures 2 of the members 1 towards the interior of the latter, and thence through the aperture 7 in the member 4 and on until the respective ends pass out from the farther ends of the first-named members. The latter are then individually or simultaneously screwed upon the member 4 and in directions opposite to one another, until the whole forms a rigidly-bound unit, in which case the individual conductors are twisted as shown, and present a union from which neither can be released by a direct pull, though all of the elements of the union can be disconnected by suitable wrenches. (*Accepted November* 29, 1916.)

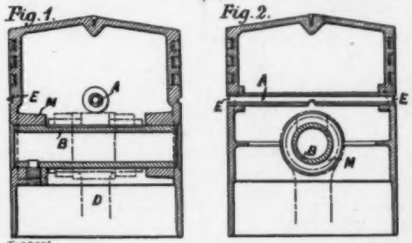
102,137. F. E. Wilson, W. A. Shepherd, and Powell and Hanmer, Limited, Birmingham. Cables. (3 *Figs.*) November 12, 1915.—The braided wire coverings employed on electric cables are difficult to finish in a neat and satisfactory manner at the ends, but the connection of such cables to other parts is rendered difficult if the ends of the braiding are left in a frayed and unfinished condition. The invention provides an end-finishing ferrule. The ferrule consists of an integral double sleeve having an inner sleeve portion *a* and a bent-over outer



capping portion or sleeve *b* of larger diameter than the inner sleeve portion, so as to form therewith an annular space for the reception of the end of the braided wire covering *d* of the cable. Slits *c* are cut in the outer sleeve to enable it to be opened when the ferrule is being applied. When in position, the inner and outer parts *a*, *b* of the ferrule are caused to closely embrace the end of the wire braiding *d*, the inner sleeve *a* being interposed between the wire braiding and the insulation of the leads *e*. (*Accepted November* 22, 1916.)

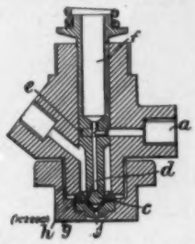
GAS ENGINES, PRODUCERS, HOLDERS, &c.

102,228. Albion Motor Car Company, Limited, and T. B. Murray, Scotstoun. Trunk Pistons. (3 *Figs.*) June 30, 1916.—This invention relates to trunk pistons having a gudgeon pin on which the small end of the connecting rod is journalled, and in which are provided pipes or passages extending inwards from a groove around the circumference of the piston. According to the invention, the groove E is immediately above the bosses M in the piston which carry the ends of the gudgeon



pin B on which rocks the small end of the connecting rod D. This groove communicates by openings through the wall of the piston with the interior thereof, and a duct A (or ducts) leads from the openings and discharges above the gudgeon pin. Oil between the piston and its cylinder walls passes into the groove around the piston and, on explosion of the charge, is blown inwards through the duct or ducts on to the gudgeon pin, thereby effectively lubricating the bearing on the connecting rod end. (*Accepted November* 29, 1916.)

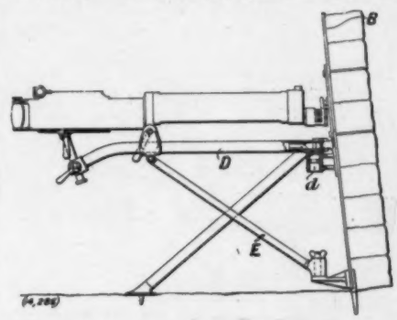
102,200. E. Gardner, Patricroft. Fuel Injectors. (1 *Fig.*) March 14, 1916.—This invention relates to fuel injectors for internal combustion engines, and particularly to fuel injectors of the known type which deliver two fuels, one a readily ignitable fuel for ignition purposes and the other a less readily ignitable fuel for power purposes, the former fuel being delivered slightly in advance of the latter. The invention comprises the arrangement whereby the ignition fuel is delivered from the interior of the injector control valve adjacent to the valve seat, so that when the said valve is opened by the fuel pressure in the ordinary manner, the ignition fuel is projected into or towards the valve-seating ring or like part, and issues the first from the injector, without being dispersed into the injector body where it would become mixed with the power fuel. An inlet port *a* for the ignition fuel is provided in the injector body. The injector control valve *e* is provided with a fuel passage *d* co-axial there-through, which receives its fuel supply from the inlet port by way of a peripheral groove *e* around the piston portion *f* of the valve stem, and which delivers its fuel into the valve-seating ring *g* through a plurality of radial downwardly inclined



passages h terminating on the inlet side of the valve seat. The upper surface of the valve seating *g* preferably tapers sharply downwards as shown, so that when the valve is opened by the fuel pressure in the ordinary manner the downwardly projected ignition fuel jet or jets coming from the valve will issue into the said ring and be directed towards the apertures leading to the tangential grooves whereby the fuel is given a swirling motion as it issues from the aperture *j*. (*Accepted November* 29, 1916.)

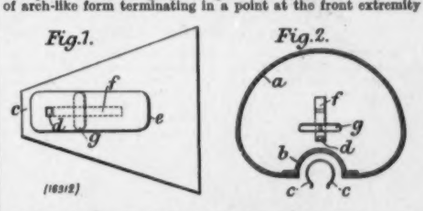
GUNS AND EXPLOSIVES.

14,286/15. Sir A. T. Dawson and G. T. Buckham, London. Automatic Guns. (3 *Figs.*) October 8, 1915.—The mounting of the gun is so constructed and arranged that the gun is supported thereby in a position that its muzzle is situated behind the shield B. The axis *d* about which the gun moves in training intersects, or approximately intersects, the axis of the gun at a point situated at or near the muzzle. The firing



port in the shield can therefore be made of small width, and the gunner can thus be effectively protected. The gun may be trunnioned to a training bar D, whose forward end may be detachably pivoted at *d* to the near face of the shield. Pivotally connected to the said bar is a forwardly and downwardly extending strut E, whose forward end is pivotally supported by the shield at the lower part thereof. (*Accepted November* 15, 1916).

16,312/15. A. E. Thorneycroft, Birmingham. Rifles. (6 *Figs.*) November 19, 1915.—According to this invention, a shield or combination shield and sighting device for rifles is of substantially conical form provided with a sighting or peep hole, means being provided whereby it can be fitted to any rifle at a position immediately behind the rear sight. The shield *a*, which may be made of sheet steel or the like, consists of a triangular base piece with one angle pointing forwardly, and a cover portion of arch-like form terminating in a point at the front extremity



whilst rising rearwardly and expanding rearwardly to a size sufficient to shield the upper part of the user's head. As shown, the device is built in two parts, the main shield portion *a* and an underside part *b* which is shaped to fit upon the top of the rifle barrel and which is riveted to the part *a*. For securing the shield upon the rifle, spring arms *c*, *c*, which clip around the barrel immediately behind the rear sight, are provided. The device is provided with an adjustable sighting hole *d* formed in a slide *e* connected to the part *a* by the slot *f* and securing member *g*; the slide is raised or lowered according to the range required. (*Accepted November* 22, 1916.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

17,310/15. E. S. Luard and G. H. Willans, London. Shaft Couplings. (7 *Figs.*) December 9, 1915.—Broadly stated, the coupling means, according to this invention, comprises or consists of a groove or channel in the exterior of one part, an internal corresponding groove or channel in another part, a plurality of balls or the equivalent in the channel or race formed when the parts are brought together, at least one suitably shaped member adapted to be driven between adjacent balls so as to jam said balls tightly against one another and some against the wall of one groove or channel and some against the wall of the other groove or channel, and means for forcing said member inwardly between balls. 1 are portions of two shafts to be coupled together. Adjacent the end of each shaft, annular grooves 2, 2, are turned. A corresponding number of similar grooves 3, 3, are turned in the inner periphery of a coupling sleeve or cylinder 4, which embraces the adjacent end portions of the shafts 1, 1. Radial holes 5 are drilled through the coupling sleeve at each

channel 3. The parts being brought together with the grooves 3 in the sleeve 4 registering with the grooves 2 in the shaft portions 1, 1, the requisite number of balls 6 is inserted into each channel through the holes 5, and said holes 5 are closed by the screwed plugs 7. The inner ends of these screwed plugs 7 project into the grooves and between certain of the balls 6, and said inner ends are tapered or coned. The plugs 7 are screwed in to the desired extent, but not so far as to cause the parts to be held against relative rotary movement. The parts are then adjusted and the

Fig. 1.

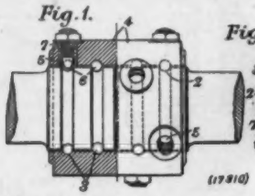
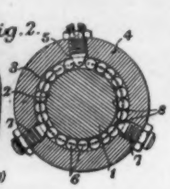


Fig. 2.



tapered plugs 7 screwed home as far as possible. The inward movement of the tapered plugs causes the balls 6 to jam one against another laterally in their respective channels, and by the lateral pressure of the balls against one another one ball will tend to force the adjacent ball inwardly or outwardly in a radial direction, and the balls will thus be so firmly jammed against one another and against the sleeve 3 and shaft portions 1, 1, that the parts will be effectively locked together. (*Accepted November* 29, 1916.)

MINING, METALLURGY, AND METAL WORKING.

102,234. The Clyde Furnace Company (A), Limited, and W. Dixon, Glasgow. Open-Hearth Regenerative Furnaces. (2 *Figs.*) July 22, 1916.—This invention relates to the repair of blocks of regenerative open-hearth furnaces whilst the furnace is working. *a* is the furnace, *b* a furnace door, *c* the working bed or hearth, *d* the air port, *e* a gas port and *h* the centre. In the arrangement shown, the centre *h*, which is preferably made of metal, has an inclined slot *k* made in it,

Fig. 1.

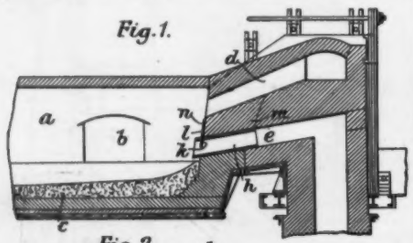
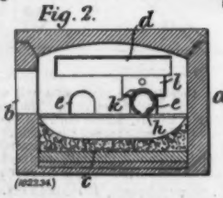


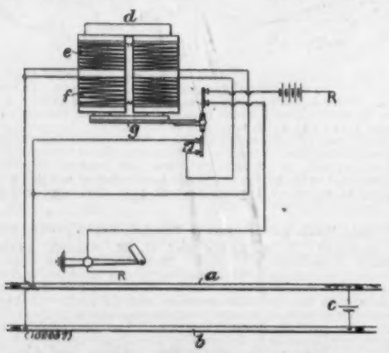
Fig. 2.



and into this slot a retaining plate *l* is inserted. As will be seen, this plate lies at a suitable angle (usually the angle of the face of the block) and forms a support for plastic material *m*, which is filled in at the back thereof and on the top of the centre. By the time both the centre and the plate are burned away the refractory plastic material has solidified and is left in position. The plate *l* may have a hole *n* in it for purposes of manipulation. (*Accepted November* 29, 1916.)

RAILWAYS AND TRAMWAYS.

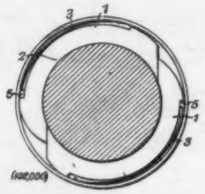
102,087. W. R. Sykes Interlocking Signal Company, Limited, and R. W. Tarrant, London. Railway Signalling. (1 *Fig.*) February 26, 1916.—A track-relay for use in a railway track-circuit system for the automatic electric control of a signal has two windings respectively adapted to create magnetic polarities of opposite sign in the relay core, the strengths of the mutually-opposed magnetic fields being so adjusted as to counter-



act, as far as is consistent with non-interference with the proper working of the relay, the tendency of the core to become permanently magnetised. In the drawing, *a* and *b* are the respective track-rails of an insulated block-section of the railway, *c* is the track-circuit battery connected across the rails *a*, *b* at one end of the section, and *d* is the track-relay at the other end of the section. The relay *d* has two windings *e* and *f*, which are superposed one upon the other in parallel. The one winding *e* is permanently in circuit, its opposite ends being connected to the respective track-rails *b* and *a*. The other winding *f* is in circuit only so long as the relay-armature *g* occupies the normal or attracted position wherein it is shown; one of its ends being connected to the track rail *b* whilst the other end is connected to one of a pair of contacts 17, whereof the other is connected to the track-rail *a*. Only when the armature *g* is in the attracted position does a neutralising-switch, operated by the movement of the armature, establish connection between the contacts 17. (*Accepted November* 22, 1916.)

STEAM-ENGINES, BOILERS, EVAPORATORS, &c.

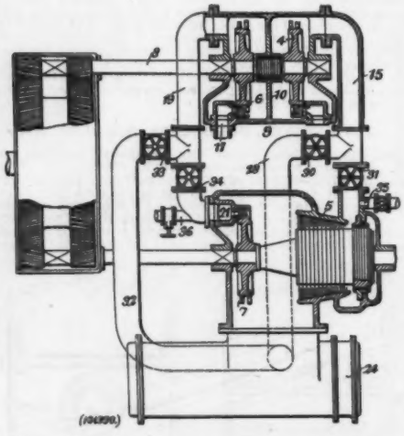
102,000. J. L. Paxton, Omaha. Piston Rod Packing. (2 *Figs.*) February 19, 1916.—This invention relates to piston rod packing of the type comprising a ring formed of arcuate sections, each having a bevel at one end with the inclined face of the bevel facing outward and a corresponding bevel at the other end with the inclined face facing inwards, each bevelled surface lying substantially at a tangent to the surface of the



piston rod 2, and the inwardly facing inclined face of each section overlying the outwardly facing inclined face of the adjacent section. The invention consists in the employment of a leaf spring 3 for each packing ring section, which is arranged to press at substantially the centre of the section and is prevented from circumferential movement by being located in a circumferentially elongated recess 5 in the periphery of the section. (*Accepted November* 15, 1916.)

SHIPS AND NAUTICAL APPLIANCES.

101,930. F. W. Le Tall, London (*The Westinghouse Machine Company, East Pittsburg, U.S.A.*). **Marine Turbines.** (1 *Fig.*) May 5, 1916.—This invention relates to turbines for marine propulsion in which both the ahead and astern turbine elements are divided into sections which are located in separate casings. The ahead turbine has a high-pressure stage 4 and a low-pressure stage 5. The astern turbine is a multiple-stage impulse turbine with the high-pressure stage 6 located in the same casing with the high-pressure stage 4 of the ahead turbine, and the low-pressure stage 7 located in the same casing with the low-pressure stage 5 of the ahead turbine. The stages 4 and 6 of the ahead and reversing turbines respectively are provided with a common shaft 8, and the common casing 9 is provided, intermediate its ends, with a diaphragm 10, which divides the interior of the casing into two compartments, one enclosing the stage 4 and the other stage 6. Mounted on the diaphragm 10 is a packing which forms a fluid-tight joint between the diaphragm and the shaft 8. Steam, after having traversed the high-pressure stage 4, is delivered through the passage 15 to the low-pressure stage 5, and is finally exhausted into the condenser 24. Steam delivered to the

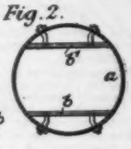


port 17, after traversing the high-pressure stage 6 of the astern turbine, is delivered through the passage 19 to the low-pressure stage 7, and is finally exhausted to the condenser. A by-pass 28 communicates with the passage 15 and with the inlet of the condenser 24, and is so arranged that it is capable of by-passing steam discharged from the high-pressure stage 4 around the low-pressure stage 5 direct to the condenser. Communication between the by-pass 28 and the passage 15 is controlled by a valve 30, and communication between the passage 15 and the inlet port of the stage 5 is controlled by a valve 31, so located that when it is closed and the valve 30 is open, steam issuing from stage 4 will pass directly to the condenser. A by-pass 32 is shown for the reversing stage 7 which communicates with the passage 19 from the reversing stage 6 and with the inlet of the condenser, and is provided with a control valve 33. A valve 34, similar to the valve 31 in the passage 15, is provided in the passage 19 between the inlet to the by-pass 32 and the inlet port 21 to the low-pressure stage 5, so that when the valve 34 is closed and the valve 33 is open, steam exhausted from the high-pressure stage 6 of the astern turbine will pass directly to the condenser. (*Accepted November* 8, 1916.)

101,944. H. D. Fitzpatrick, Glasgow. (*A. W. Robinson, Montreal, Canada.*) **Suction Dredgers.** (2 *Figs.*) July 3, 1916.—As will be seen from the drawings, the discharge pipe *a* of the suction pump is provided with a liner *b* extending along the bottom, the liner being constituted by one or more flat metal plates. These plates rest against the inside of the pipe and extend across the same at a few inches from the bottom. It is found advisable to make the plates removable, and to this end they are fastened, at intervals, by means of bolts and nuts. The plates *b* cut off a segmental portion of the pipe which at present is apt to pack full of sand or gravel or other material, which gradually

Fig. 1.

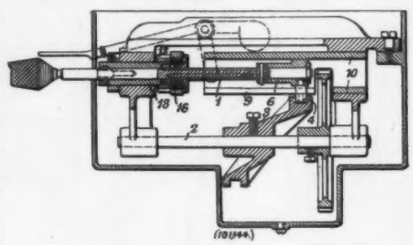
Fig. 2.



tends to choke the pipe unless the same is cleaned out at intervals, which, in the case of a long discharge pipe or pipe line, causes considerable trouble and expense. A second liner b^1 may also be employed. (*Accepted November* 8, 1916.)

TEXTILE MACHINERY.

101,144. Maschinenfabrik Schweiter A.G., Horgen, Switzerland. Pirn Winding Machines. (4 *Figs.*) August 6, 1915.—This invention relates to an improved drive for actuating the spindle shaft of winding machines in which the winding spindle performs a rotary movement in addition to an axial movement. In winding machines of this kind the defect has shown itself that, owing to the rotary motion and to the simultaneous axial movement of the winding spindle shaft, friction is set up which has a detrimental effect on the formation of the pirn or cop. Many attempts have been made to reduce this friction, but were unsatisfactory because the construction took up considerable space, the saving of which plays a great part in winding machines. The object of the present invention is to overcome these defects, and the invention lies substantially in the fact that the rotary motion of the spindle shaft is imparted to it by a ball or balls freely disposed in a rotary sleeve on the



spindle shaft engaging axial grooves in the spindle shaft. The spindle 1 receives its axial reciprocating motion by means of a grooved cam 3 on the shaft 2. The spindle 1 carries at its rear end a sleeve 6, which is provided with a pin carrying a roller 4, which engages the groove in the cam 3. The spindle lies loose inside the sleeve 6 and is provided at the end with a nut, whilst at the opposite end of the sleeve 6 a stop ring is secured to the spindle. The sleeve 6 moves in a guide 10 provided at the bottom with a slot 9 to guide the enlarged portion of the pin carrying the roller 4. A sleeve 13 is loosely mounted on the forepart of the spindle, which sleeve is rotatable, but not slidable in relation to the frame, and carries a toothed wheel 12 at one end. A box 16, similar in form to a ball-cage, is built into the other end of the sleeve 13. This box has three holes, in which balls are freely carried. The spindle 1 has three longitudinal grooves which serve to receive the inner half of the balls. When the sleeve 13 is rotated, the balls cause the spindle 1 to rotate without thereby hindering the spindle in its axial movement. Owing to the balls being loosely carried, they can move freely and the friction is reduced to a minimum. (*Accepted November* 1, 1916.)

MISCELLANEOUS.

101,843. T. Sloper, Devizes. Aeroplane Wheels. (2 *Figs.*) October 25, 1915.—According to this invention, a wire-wheel with a side drum attached for braking purposes is characterised by radial spokes which connect the rim and hub, such spokes being carried slidingly through the drum to secure it against lateral displacement, and the provision of other means to secure the drum centrally relatively to the wheel-rim, for the purpose of providing a light wheel and drum which can be readily trued. The wheel hub A is connected to the rim B by spokes B^1.

Fig. 1.

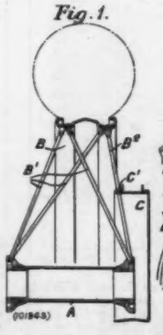
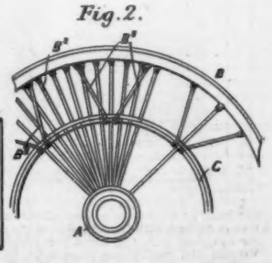


Fig. 2.



These spokes all lie clear of the brake-drum C. The side of the wheel on which the brake-drum is attached, however, is provided with a series of radial spokes B^2 which extend from the rim B to the hub A and pass through a lip C^1 of the drum C. These spokes B^2 secure the drum against displacement in the direction of the axis of the hub A, and other short tangential spokes B^3 extend from the rim B to the lip C^1 of the drum C and secure the drum in a central position relatively to the rim B. (*Sealed.*)